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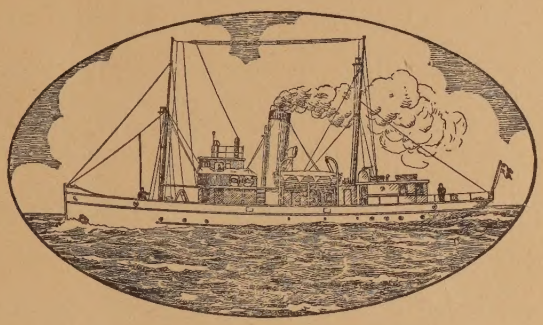
Report

of

The Danish Biological Station

to

The Ministry of Fisheries



No. 51

By

H. Blegvad, Ph. D.
Director

Copenhagen. C. A. Reitzel.
1950.

The Reports from the Danish Biological Station (Nos. I—XXI) are published in the official Danish "Fiskeri-Beretning" for the years 1890—91 until 1912. After this year they appear as special publications. The Reports I—XXXII are edited by Dr. C. G. Joh. Petersen, the Reports XXXIII—XXXVI by Dr. A. C. Johansen and the later Reports by Dr. H. Blegvad.

I. *C. G. Joh. Petersen:* Fiskenes biologiske Forhold i Holbæk Fjord. (1890—91)*) 63 pp. 1 Chart. Out of print.

II. *Idem:* On the Eggs and Breeding of our Gobiidæ. (1891—92.) 9 pp. Two Plates. Out of print.

III. *Idem:* The Pelagic Life in Fænø Sound etc. (1892—93.) 38 pp. Tables. Out of print.

IV. *Idem:* On the Biology of our Flat-fishes and on the decrease of our Flat-fish Fisheries. (1893—94.) 146 pp. 2 Plates. 1 Chart. Many Tables. Out of print.

V. *Idem:* The common Eel (*Anguilla vulgaris* T.) gets a Particular Breeding-dress before its Emigration to the Sea. (1894—95.) 35 pp. With 2 Plates.
Etc. 64 pp. Out of print.

VI. *Idem:* The Yearly Immigration of young Plaice into the Limfjord etc. (1895—96). 48 pp. 1 Chart. 2 Tables. Out of print.

VII. *Idem:* Plankton-Studies in the Limfjord. 1897. 23 pp. 1 Map. 4 Tables. Out of print.

VIII. *Idem:* An Otter-Seine for the Exploration of Deeper-Seas. 1898. 24 pp. With 10 Figures. Out of print.

IX. *Idem:* Trawlings in the Skager Rack and the Northern Cattegat in 1897 and 98. 1899. 56 pp. With one Map. Out of print.

X. *Idem:* List of the "Aalerusestader" in Denmark etc. — Smaller Communications. 1899 and 1900. 37 pp.

XI. *Idem:* I. The Biology of the Cod in the Danish Seas. II. On other Codfishes in our Seas. III. Some General Observations on Protection, Legislation etc. IV. Alterations and Improvements on Otter-seines for Zoological Purposes. 1900 and 1901. 44 pp.

XII. *Idem:* I. Where, and under what Conditions, can the Eggs of Plaice be developed into Young Fish within the Skaw? II. On the Young Stages of the genus *Zeugopterus.* (With one Plate). III. Can we enter into Competition with the Foreign Steam-trawlers in our Seas outside the Danish Territorial Limit. 1902 and 1903. 33 pp.

XIII. *A. Otterstrøm:* Eggs and Young of Fishes in the Danish Waters. (Investigations during 1904 and earlier years.) 1903 and 1904. 85 pp.

XIV. I. *C. G. Joh. Petersen:* The Influence of Light on the Migrations of the Eel. II. *K. I. Gemzøe:* Age and Rate of Growth of the Eel. 1906. 39 pp.

XV. *Idem:* I. First Report on the Oysters and Oyster Fisheries in the Lim Fjord. (70 pp.) 1908.

XVI. *C. H. Ostenfeld:* On the Ecology and Distribution of the Grass Wrack (*Zostera marina*) in Danish Waters. With 9 figures. 1908. 62 pp.

XVII. *C. G. Joh. Petersen:* II. Second Report on the Oyster and Oyster Fisheries in the Lim Fjord. 1908. (24 pp).

XVIII. *C. G. Joh. Petersen:* I. The Yield of the Limfjord fisheries in recent years and the transplantation of Plaice in 1908. With 6 tables and 1 Chart. II. Biological investigations on the stock of Plaice in the Limfjord. With 3 Tables. III. The Yield of the Prawn fishery from 1885—1907 and its improvement by means of protection. With 3 Tables. 25 pp. 1909.

XIX. *Idem:* Some Experiments on the Possibility of combating the harmful Animals of the Fisheries, especially the Whelks in the Limfjord. 20 pp. 1911.

XX. *C. G. Joh. Petersen* og *P. Boysen Jensen:* Valuation of the Sea. I. Animal Life of the Sea-Bottom, its food and quantity. With 6 Tables, 3 Charts and 6 Plates. 81 pp. 1911.

XXI. *C. G. Joh. Petersen:* Valuation of the Sea. II. The Animal Communities of the Sea Bottom and their importance for marine Zoogeography. With 6 Plates, 3 Charts and an Appendix. 110 pp. 1913.

XXII. I. *P. Boysen Jensen:* Studies concerning the organic matter of the Sea Bottom. II. *H. Blegvad:* Food and Conditions of Nourishment among the Communities of invertebrate animals found on or in the sea bottom in Danish waters. III. *C. G. Joh. Petersen:* The Work of the Biological Station from 1889—1914. With Illustrations and Tables.

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*) The figures in ( ) refer to the "Fiskeri-Beretning" for the years quoted.

Report

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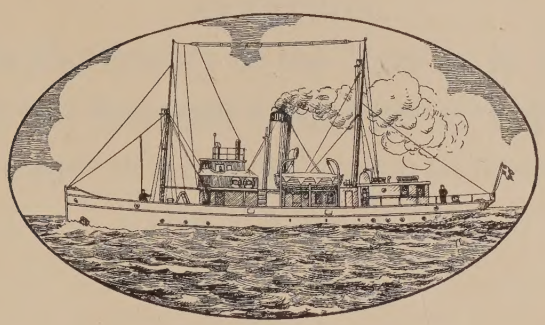

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Changes in the Quality of the Herring in the Course of the Year and from Year to Year.

By

AAGE J. C. JENSEN

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The importance of the changes in quality. The maturity stages of the herring.

The changes in the quality of the herring during its development are greater than the corresponding changes in most other fishes. They are the more conspicuous because in most localities it is possible at any season to take herring at all stages of maturity though in the same shoal and, accordingly, in each catch they are often of one quality or practically of two qualities only. In many cases the difference in quality is so great, that it has led to the gratuitous supposition that a difference in the quality of herring caught in the same locality is indicative of its belonging to different tribes or races.

Therefore the herring brought into the market are not only divided into size groups like other fishes; a distinction is also made between fat herring or mattie, filling-herring, full herring, blood-herring and spent herring.

However there are also great changes from year to year in the quality of herring at the same stage of maturity. The changes in maturity form the basis of the examinations on weight and content of fat.

For the classification of the maturity I have used Johansen's scale[1]). As regards the herring that are not full, spawning or spent it differs from the scale agreed upon by the Conseil International pour l'Exploration de la Mer in 1930[2]). The latter is practically identical with the scale published by Hjort[3]) and was formulated more precisely by Lovern and Wood[4]). In some cases it gives only the central points of the maturity groups while Johansen's scale always gives the lines of demarcation between them. Johansen's classification was used in all previous Danish investigations. As mentioned by Gilson[5]) the international scale from 1930 was: Hjort's scale with small alterations in connexion with Johansen's scale in doubtful cases. In some respects there is a rather considerable difference between Johansen's scale and the international one, for which reason they are compared on the following page.

According to Johansen's classification herring of maturity I are always young herring, those of the latter part of maturity II and of III are fat herring, of IV half-herring, of V full herring, of VII and VIII spent herring (immediately after the spawning blood-herring).

The "coefficient of nutrition".

The ratio of length to weight.

The coefficient of nutrition is a measure of the weight of the herring compared to its length and is calculated as $k = \frac{100 \cdot \varrho}{l^3}$, where ϱ stands for the weight in grammes and l for the length in centimetres. In most other species of fish it may be used as a measure of the state of nutrition of the fish, perhaps excepting the last month before the spawning. In the herring it is highly dependent on the degree of maturity, and so the term "coefficient of nutrition" is here rather misleading.

Changes in the coefficient of nutrition during the development.

The coefficient of nutrition for herring at different stages of maturity is shown in table 1 and figure 1.

[1]) A. C. Johansen: On the large spring-spawning sea-herring (*Clupea harengus* L.) in west European Waters. Medd. f. Komm. f. Havundersøgelser. Ser. Fiskeri V, 8. 1919.

[2]) E. Ehrenbaum: Proceedings. Meeting of Herring Experts, held at the Fisheries Laboratory, Lowestoft, England, Nov. 4th to 7th, 1930. Rapp. et Proc.-Verb. LXXIV, p. 116.

[3]) Johan Hjort: Report on Herring-Investigations until January 1910. Publications de Circonstance, No. 53. 1910.

[4]) J. A. Lovern and Henry Wood: Variations in the chemical composition of herring. Journal Mar. Biol. Assoc. Vol. XXII, 1938.

[5]) G. Gilson: Combined North Sea 1930. Rapp. et Proc.-Verb. LXXIV, p. 140.

Johansen's and the international scale of maturity. The figures and other statements in brackets stand for the height of the sexual organs. The horizontal lines represent the limits between the degrees of maturity.

Johansen	International
I. Young herring that have never spawned. In most cases the sex must be determined under the microscope.	I. Young herring that have never spawned. Sexual organs in the resting stage, clear wine or amber-coloured. (2—3 mm.)
(3—4 mm.)	
II. Eggs not (or hardly) visible with the naked eye. Testes mostly reddish grey.	II. Eggs visible vithout yolk (about 10 mm). Length a litgle more than half the abdominal cavity. (I) II: ripening for the first time: (VIII) II: re-maturing)
(8 mm.)[1]	
III. Eggs $^1/_5$—$^1/_2$ mm. Testes reddish grey or greyish.	III. Eggs amber-coloured, with yolk. (Half the height of the abdominal cavity)
(half the height of the abdomonal eavity)	
IV. Eggt $^1/_2$—$^4/_5$ mm. Testes whitish.	IV. No large transparent eggs. (About $^2/_3$ of the abdominal cavity)
(nearly the whole height of the abdominal cavity)	
V. Spawning not commenced. Eggs about $^4/_5$—1 mm. Testes milky white.	V. Spawning not commenced, a few transparent eggs may be found. (The whole abdominal cavity)
VI. Spawning.	VI. Spawning in progress or just imminent.
VII. Just or recently spent; the sexual organs have not yet regained their compact shape. Small remains of sperm and eggs may be found.	VII. Spent, the organs bloodshot. A few eggs left.
VIII. Re-maturing. Sexual organs of compact shape. Entering stage II.	VIII. Re-maturing with traces of fat at the intestines. Entering stage II.

[1]) In the inner Danish waters about 7 mm.

Table 1. Coefficients of nutrition at different stages of maturity in some catches. Numbers of herring in brackets.

	Maturity:	II	III	IV	V	VI	VII	VIII
Odden	2.10.41.....	0.70 (3)	..	0.71 (5)	0.76 (17)	..	..	..
Kalundborg	17.9.41.....	0.65 (20)	0.72 (10)	0.74 (10)	0.85 (1)	..	..	0.70 (1)
Nyborg	30.10.41.....	0.64 (9)	0.67 (5)	0.68 (8)	0.71 (5)	..	0.66 (3)	0.67 (12)
Dragør	23.9.41.....	..	..	0.78 (19)	..	..	0.64 (24)	..
Kalvebod	1.10.40.....	0.57 (2)	..	..	0.68 (4)	..	0.56 (36)	0.65 (4)
—	7.10.41.....	0.69 (6)	..	..	0.76 (3)	..	0.64 (12)	0.63 (29)
—	8.10.42.....	0.64 (25)	..	..	0.79 (3)	..	0.61 (43)	..
Klintholm	24.9.41.....	0.66 (2)	..	..	0.82 (29)	0.74 (2)	0.67 (12)	..
Bornholm	22.9.40.....	..	..	..	0.63 (34)	0.66 (5)	0.55 (8)	..
—	16.10.41.....	..	..	..	0.82 (5)	..	0.65 (16)	..
—	25.9.42.....	..	..	0.68 (1)	0.76 (40)	..	0.64 (2)	..

As to the localities see map Fig. 1, p. 23 in the 2nd paper of this vol. Gniben and Kalundborg: N. W. Sjælland; Nyborg: Fyn (Funen); Dragør and Kalvebod: near Copenhagen, Klintholm: S. E. Møen.

In the figure the points joined by lines show the coefficient at different stages of maturity in the same catch, no matter whether the individuals belong to the same or to different races.

It is seen that the weight of the herring as compared to its length (or rather: at the same length or referred to the same length) increases rapidly during the maturation. The rise of the coefficient of nutrition differs very much from one catch to the other, and the coefficient for full herring may range between means of about 0.70 and 0.90, a variation of more than 20 %.

Herring of less than 15 cm. in length normally have a lower coefficient than herring of about 15 cm:

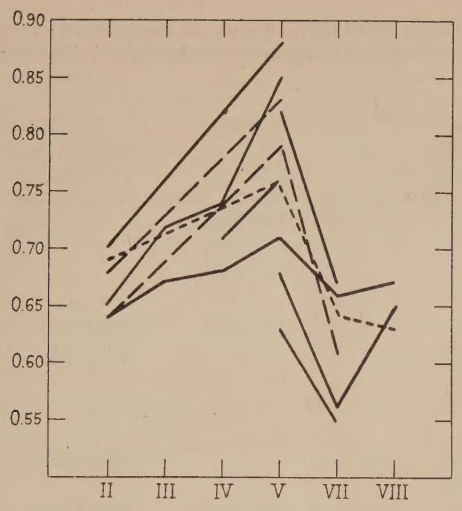

Figure 1. The coefficient of nutrition of herring at different stages of maturity in some of the catches examined.

herring of 6—12 cm., averaging about 8 cm., caught at the Scaw (Grenen) in August 1943, had a coefficient of nutrition of 0.59 (267 herring) and herring of about 14 cm., caught at the same time at Hirtshals, showed a coefficient of 0.67 (135 herring).

In most cases all herring at the different stages of maturity in the same catch have either a high, normal or low coefficient of nutrition. The lines joining the points of figure 1 do not illustrate the changes in the same herring during their growth. Beside the changes in maturity the season here plays a prominent part (cp. figure 2).

For comparison with the coefficient of nutrition of the small herring the annual variation of sprat has been plotted in figure 2 because these herring are often caught and sold together with sprat.

It is seen that the difference between winter and summer is greater in sprat than in herring and that the coefficient of nutrition for sprat is always higher than for the small herring; this is partially due to the fact that the sprat has another shape of body than the herring, but to some extent it is caused by the greater fat-content of the sprat (see p. 13).

The seasonal change in the coefficient of nutrition in herring at the same stage of maturity.

It appears from table 2 and figure 2 that the small herring of about 15 cm., which are always of maturity I, show a very distinct change in the course of the year, the lowest coefficient of nutrition mostly occurring in February, the highest about 1st August. On the whole the coefficient of nutrition for these herring in January—February seems to be a little lower in the southern Kattegat and the Belt Sea than in the northern Kattegat and the Skagerrak, but from April to September it is higher in the southern area.

The coefficient of nutrition for the herring of about 20 cm. of maturity I—II in winter has been somewhat higher in the Skagerrak than for the smaller herring. From the winter months there are no examinations from the inner waters for this group.

For maturity III there are only a few determinations of the coefficient of nutrition. It is a little higher than for maturity II, but lower than for maturity IV. For the maturities IV, V and to some extent for the beginning VI examinations from the Skagerrak show coefficients of nutrition of about 0.8 both from October and February, but in the inner waters there seems to be a seasonal variation, the lowest coefficient of nutrition occurring from October to February with about 0.7, the highest in May—September with about 0.8. The spent herring at all seasons show a coefficient of nutrition of about 0.6. When re-maturing they once more reach the same coefficient of nutrition as herring of maturities II and III.

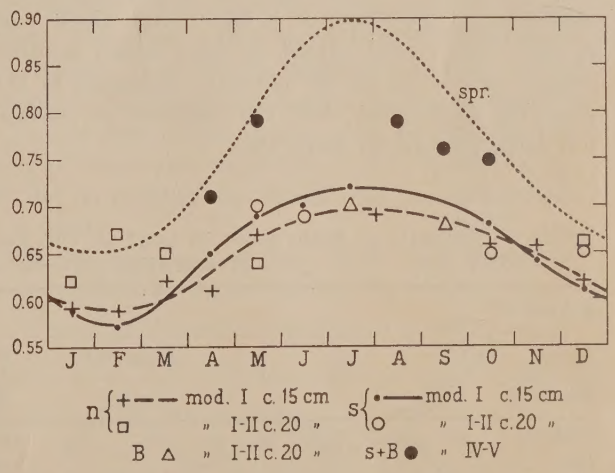

Figure 2. Annual variation of the coefficient of nutrition for the herring. *n*: the Skagerrak and the northern Kattegat, *s*: the southern Kattegat and the Belt Sea, *B*: at Bornholm. The full curve shows the annual variation in herring of about 15 cm. length in the southern Kattegat and the Belt Sea, the dashed curve the variation in herring of the same length in the Skagerrak and the northern Kattegat. For comparison's sake has been plotted the annual variation in sprat of 12—15 cm. length in the Skagerrak (the dotted curve marked spr.) (mod: maturity).

Table 2. Mean coefficients of nutrition in the individual months

Maturity:	I		I-II		
	Skagerrak northern Kattegat	S. Kattegat The Belt Sea The Sound	Skagerrak, northern Kattegat	S. Kattegat The Belt Sea The Sound	Bornholm
January	0.59 (449)	0.59 (490)	0.62 (52)	..	..
February	0.59 (857)	0.57 (477)	0.67 (33)	..	..
March	0.62 (240)	..	0.65 (53)	..	..
April	0.61 (469)	0.65 (296)	..	..	..
May	0.67 (150)	0.69 (285)	0.64 (65)	0.70 (32)	..
June	..	0.70 (345)	..	0.69 (4)	..
July	0.69 (227)	0.72 (30)	..	..	0.70 (22)
August		..	..	..	..
September	..	..	..	..	0.68 (7)
October	0.66 (433)	0.68 (599)	..	0.65 (42)	..
November	0.66 (370)	0.64 (832)	..	..	..
December	0.62 (85)	0.61 (980)	0.66 (325)	0.65 (140)	..

In the Skagerrak and the northern Kattegat every herring of 15 cm. length in June—August on an average is 20 % heavier than in February; in the Belt Sea it is a little more than 25 % heavier. In the Belt Sea 55 herring go to a kg. in winter, the number in summer being 41.

The coefficient of nutrition reaches its lowest value immediately before the beginning of the plankton production and then rises until the spring maximum of the plankton is over, after which time it falls. One would expect to have found another smaller maximum at the autumn maximum of the plankton production, but the material is perhaps not large enough to show this.

Variations from year to year in the coefficient of nutrition of the herring and their causes.

It is seen from table 3 that the variations from year to year in the coefficient of nutrition for the herring at the same season may be at least 25 % as far as the small herring are concerned.

On the face of the matter these variations must be supposed to depend either on the temperature of the water or on the conditions of nutrition.

But the variations from year to year in the temperature of the water show no correspondence with the variations of the coefficient of nutrition. 1947 was a cold winter like 1940, 41 and 42, but still the coefficient of nutrition was particularly high in 1947,

Table 3. Variations from year to year in the coefficient of nutrition for herring at different stages of maturity. Numbers of herring in brackets.

Maturity	I		IV - V (-VI)		
Area	Skagerrak	Belt Sea	Belt Sea		Bornholm
Month	Dec[1]).	March	April — May	Aug. — Oct.	Aug. — Oct.
1936	..	0.57 (321)	..	..	..
1940	..	0.63 (350)	..	0.77 (53)	0.64 (39)
1941	0,58 (134)	0.60 (401)	..	..	0.76 (60)
1942	..	..	0.73 (124)	0.81 (60)	0.76 (41)
1943	..	..	0.77 (18)	..	0.83 (8)
1944	0.57 (650)	..	0.64 (28)	0.81 (60)	0.81 (73)
1945	0.63 (222)	..	0.72 (303)	..	..
1946	0.58 (286)	..	..	..	..
1947	0.71 (88)	..	0.76 (71)	..	..
1948	0.60 (261)	0.59 (156)	..	..	..

[1]) previous year.

or herring at different stages of maturity. Numbers of herring in brackets.

IV-V (-VI)			VII-VIII			VIII-III	
kagerrak orthern Kattegat	S. Kattegat The Belt Sea The Sound	Bornholm	Skagerrak northern Kattegat	S. Kattegat The Belt Sea The Sound	Bornholm	Skagerrak northern Kattegat	S. Kattegat The Belt Sea The Sound
..	..	..	0.58 (45)	..	..	0.74 (7)	..
.78 (3)	..	..	..	..	..		..
..	..	..	..	..	..	..	..
..	0.71 (424)	..	..	..	..	..	..
..	0.80 (79)	0.72 (8)	..	..	..	..	..
..	..	..	..	..	0.57 (42)	..	0.72 (44)
..	..	..	..	..	..	..	..
..	0.80 (80)	0.79 (104)	..	..	..	..	..
..	0.80 (122)	0.71 (102)	..	0.65 (35)	0.57 (10)	..	..
.82 (49)	0.74 (51)	0.80 (15)	0.64 (7)	0.61 (140)	0.65 (16)	0.80 (10)	0.69 (17)
..	..	..	..	..	..	..	..
..	..	..	0.62 (3)	..	..	..	..

but low in 1940 and 41. Likewise, there is no correspondence with the summer temperature in the upper or lower water layer.

However, there is a very distinct correspondence between the variations in the coefficient of nutrition in winter and spring and the variations in the salinity of the lower water layer during the previous autumn and winter months (see figure 3). The salinity is a measure of the intensity of the inward current through the Skagerrak and the Kattegat. This current carries with it nutritary salts (nitrates and phosphates) from the deep water layers of the Skagerrak[1]), and a strong inflow will therefore mean better conditions of growth to the phytoplankton and, consequently, to the animal plankton during the immediately following time.

The fat-content of the herring.

For about 60 of the samples of herring, in which maturity, race, etc. were examined, Fiskeriministeriets Forsøgslaboratorium (ɔ: the experimental laboratory of the Ministry of Fisheries) has determined the fat-content. To begin with these determinations were made according to Wimpenny's method by extraction with ether[2]), later on by grinding and extraction with benzene. The results of these examinations are given in Table 4. Moreover Director Fr. Bramsnæs has most kindly put at my disposal the results of a large number of fat determinations of herring from the trawl fishery in the North Sea in 1947 and 1948 (63 and 94 samples, respectively) and from the Skagerrak and the northern Kattegat in the seasons 1947—48 and 1948—49 (24 and 32 samples of market-herring, respectively). These samples were collected by the Fishery Patrol in a way as to be representative of the catches, most of the samples consisting of 10 herring. At the laboratory the herring were measured, and notes were taken to the effect of showing how many of them were immature, full or spent herring, but the fat-content was determined for each sample as a whole.

The examinations of the North Sea herring in

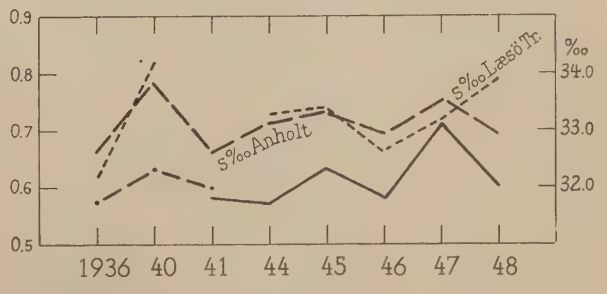

Figure 3. The coefficient of nutrition in herring of about 15 cm length from January—April (dashed graph: in the Belt Sea, full graph: in the Skagerrak) compared to the bottom salinity at Læsø Trindel and Anholt Knob in October—December of the previous year.

[1]) E. Steemann Nielsen: Die Produktionsbedingungen des Phytoplanktons im Übergangsgebiet zwischen der Nord- und Ostsee.—Medd. f. Komm. f. Danmarks Fiskeri- og Havundersøgelser. Ser. Plankton. III, 4. 1940.

[2]) R. S. Wimpenny: A Routine Method for the Estimation of Fat in Plankton and its Application to Herring Tissues. Journal du Conseil XII, p. 339. 1938.

Table 4. Fat-content of herring examined to race.

Date Year	Locality	Length cm.	Maturity	Fat %
	North Sea.			
27.8.47	58°50′ n. lat.–0°05′ e. long.	ca. 26	III	16,8
—	—	ca. 26	V	16.4
25.9.48	58°00′ n. lat.–1°00′ e. long.	..	III	13.0
—	—	..	V	12.5
—	—	..	VII–VIII	8.5
7.10.48	N. of Middle Rough	..	V	13.0
—	—	..	VII	7.7
—	—	..	VIII	15.2
	Northern Kattegat, Skagerrak. Foodfish.			
26.11.46	Eastern Skagerrak	16–18	I–II	4.0
—	—	22–28	VII	2.4
6.1.47	W.N.W. of. the Scaw, 75 m	ca. 26	VII	1.8
23.1.47	N.W.by.W.of the Scaw,90 m	16–18	I–II	4.9
—	—	22–27	II–III	4.9
27.1.47	N. of Hirtshals, 75 m.....	16–18	I–II	7.1
—	—	26–28	VII	3.4
12.2.47	Off. Hirtshals	16–18	I–II	3.3
—	—	19–24	III	5.8
—	—	29	VIII	2.4
18.3.47	N.N.E. of Hirtshals, 65 m	16–18	II	3.0
—	—	19–24	II, III	3.8
—	—	29	VII, VIII	2.7
25.3.47	N.N.E. of Hirtshals, 65 m	15–20	I–II	2.1
—	—	24–28	VIII	1.6
4.5.47	W. of Hirtshals, 70 m.....	18–22	I–II	2.2
3.12.47	N.W. of the Scaw, 75 m ..	19–21	II	13.6
—	— ...	20–24	II, III	26.9
3.12.47	N.W. of the Scaw, 75 m ..	23–27	III, IV	19.6
16.12.47	N.W. of the Scaw, 95 m ..	23–27	II, III	14.2
—	— ..	27–29	VII	8.3
4.2.48	S.E.by E. of the Scaw, 45 m	17–21	II–III	5.4
—	—	28	VIII	2.7
17.2.48	N.W. of the Scaw, 115 m .	22–24	II–III	9.9
—	— ..	ca. 26	VIII	8.9
24.2.48	N.W. of the Scaw, 85 m ..	ca. 20	II	6.7
—	— ..	ca. 24	VIII	7.2
6.4.48	E. of the Scaw, 45 m.....	22–24	II	4.0
20.12.48	—	ca. 27	VII	7.3
30.1.49	—	ca. 24	II	6.7
—	—	ca. 27	VII	6.5
—	—	ca. 27	VIII	5.7
18.2.49	N.W.byN.of the Scaw,115m	20–21	II	6.0
—	—	25–29	VII	4.0
28.2.49	N.N.W. of the Scaw, 115 m	18–21	II	2.3
—	—	25–27	VII	1.8
	Northern Kattegat, Skagerrak. Fish for processing			
18.11.47	S.S.E. of the Scaw, 33 m .	ca. 12	I	5.2
19.2.47	S.S.E. of the Scaw, 23 m..	ca. 13	I	8.1
4.2.48	S.E. by.E of the Scaw, 45 m	10–15	I	2.5
6.4.48	E. by S. of the Scaw, 47 m	ca. 14	I	4.0
7.4.48	— .	ca. 14	I	2.6
26.10.48	S.S.E. of the Scaw, 23 m ..	10–14	I	4.6
7.2.49	E. of the Scaw, 30 m.....	ca. 14	I	2.3
23.3.49	E.by S. of Frederikshavn, 40 m	11–13	I	0.7

Table 5. Mean values of fat-content (in per cent.) in catches from the North Sea, irrespective of degree of maturity. Numbers of samples in brackets. (Fiskeriministeriets Forsøgslaboratorium).

Northern lat.	Year	$^{20}/_{7}$—$^{31}/_{7}$	$^{1}/_{8}$—$^{15}/_{8}$	$^{16}/_{8}$—$^{31}/_{8}$	$^{1}/_{9}$—$^{15}/_{9}$	$^{16}/_{9}$—$^{30}/_{9}$	$^{1}/_{10}$—$^{31}/_{10}$
59°–60°	1947	..	16.2 (4)	13.8 (2)	13.3 (2)	13.7 (2)	..
	1948	..	12.1 (14)	13.1 (8)	..	..	..
58°–59°	1947	22.2 (5)	18.4 (15)	16.9 (9)	13.5 (6)	13.9 (4)	..
	1948	..	13.3 (17)	12.4 (16)	11.9 (22)	13.5 (2)	..
57°–58°	1947	18.1 (1)	..	..	14.1 (1)	..	..
	1948	..	..	..	..	..	..
56°–57°	1947	..	..	..	15.4 (3)	..	16.1 (1)
	1948	..	..	..	..	..	11.6 (1)
55°–56°	1947	..	..	..	..	14.1 (3)	11.8 (3)
	1948	..	..	..	..	13.0 (1)	9.6 (5)
54°–55°	1947	..	..	..	..	..	11.0 (2)
	1948	..	..	..	..	..	..

Table 4. Fat-content of herring examined to race.

Date Year	Locality	Length cm.	Maturity	Fat %
	The Limfjord, Ringkøbing Fjord.			
26.11.46	Fur Snævring	ca. 14	I	2.4
9.12.46	Risgaards Broad	ca. 13	I	6.1
21.1.47	Sallingsund	9–10	I	0.8
—	—	13	I	1.8
—	—	16–17	I–II	1.3
20.5.47	At Junget Øre	ca. 24	VII	2.4
28.2.48	Sallingsund	8–10	I	2.3
—	—	15–18	I–II	3.9
?.4.48	At Gjøl	ca. 24	V	7.5
12.4.48	At Fur	ca. 24	V	8.0
—	Ringkøbing Fjord	ca. 24	VIII, III	6.3
20.4.48	At Skive	ca. 24	V	5.4
—	—	ca. 26	VIII	2.0
	Southern central Kattegat.			
24.10.46	At Odden	12–20	I, II, III	4.5
20.5.47	At Tisvilde	ca. 22	IV, V	2.3
28.10.47	At Hundested	ca. 14	I	1.1
—	—	ca. 22	II, III	6.5
—	—	ca. 22	V	6.8
9.5.48	—	9–19	I–II	7.1
—	—	20–22	V–VI	5.1
—	—	24–26	V–VI	8.1
26.10.48	The Isefjord	19–20	II	7.8
—	—	23–25	VIII	10.8
21.12.48	At Hundested	ca. 20	II	8.2
7.3.49	—	13–16	I	1.3
—	—	19–21	II	4.0
—	—	19–21	III	5.1
	Western Baltic, the Belts.			
15.5.47	At Assens	ca. 19	ca. II	11.9
—	—	ca. 25	III	9.3
22.11.47	Off. Flensborg Fjord	ca. 13	I	5.6
—	—	ca. 20	II	9.6
—	—	ca. 22	VII	2.0
6.12.47	At Bogense	ca. 13	I	5.4
19.10.48	At Kerteminde	ca. 15	I	13.6
27.10.48	At Aarhus	ca. 15	I	6.6
15.11.48	At Assens	18–20	I–II	6.5
—	—	23–24	V	6.9
16.12.48	At Kerteminde	ca. 14	I	12.0
3.1.49	—	11–15	I	3.7
18.1.49	—	11–16	I	3.8
17.3.49	—	11–14	I	2.8
	At Møn.			
17.7.47	At Klintholm	ca. 23	II–III	11.3
12.7.48	—	ca. 22	ca. III	11.7
	At Bornholm.			
10.6.47	W. of Rønne	ca. 20	VII–VIII	6.6
—	—	ca. 24	VII–VIII	6.9
10.6.48	N.W. of Rønne	ca. 20	II–III	15.8
—	—	ca. 24	VIII	16.0
11.10.48	At Teglkaas (W. Bornh.)	ca. 23	V	8.6
—	—	ca. 23	VII	5.7
—	—	ca. 23	VIII	9.5
10.5.49	W. of Rønne	ca. 23	III–IV	7.1
—	—	ca. 23	V	8.4

Table 6. Percentage amounts of immature, full and spent herring in samples from the North Sea, examined by Fiskeriministeriets Forsøgslaboratorium.

	immature		full		spents	
	1947	1948	1947	1948	1947	1948
July	..	98	..	..	..	2
Aug.	36	43	61	36	3	21
Sept.	24	22	71	41	19	37
Oct.	5	4	57	53	39	43

1947 were dealt with by Knud Nielsen, C. E.[1]). The whole material of Forsøgslaboratoriet is represented in tables 5, 6 and 7.

At the end of July 1948 ($^{20}/_{7}$—$^{1}/_{8}$) fishing was carried out off Egersund on the western side of the Norwegian Channel at depths of 150—200 m. Here the herring were mostly immature and 22—25 cm. long. Their fat-content was 11.4 % (8 samples).

[1]) Knud Nielsen: Fedtindholdet af nordsøsild 1947.— Medd. nr. 74 fra Fiskeriministeriets Forsøgslaboratorium. April 1948.

Table 7. Fat-content (in per cent.) in catches of adult herring (food fish) from the Skagerrak and the northernmost Kattegat. Numbers of samples in brackets. (Fiskeriministeriets Forsøgslaboratorium).

	Depth m.	Fat % mean	Fat % from—to
1.–14. feb. 1948	28– 47	4.8 (3)	1.8–7.3
15.–29. — —	45–115	6.2 (13)	2.4–9.2
March 1948	45–115	6.0 (8)	3.5–8.8
December 1948	70– 80	4.4 (2)	4.4–4.5
January 1949	110–200	5.7 (7)	3.2–7.2
1.–14. feb. 1949	50–190	3.1 (6)	1.0–5.7
15.–28. — —	32–130	2.2 (8)	0.6–5.1
March 1949	45– 70	1.5 (6)	1.0–2.3
April —	28– 68	1.1 (3)	0.1–2.8

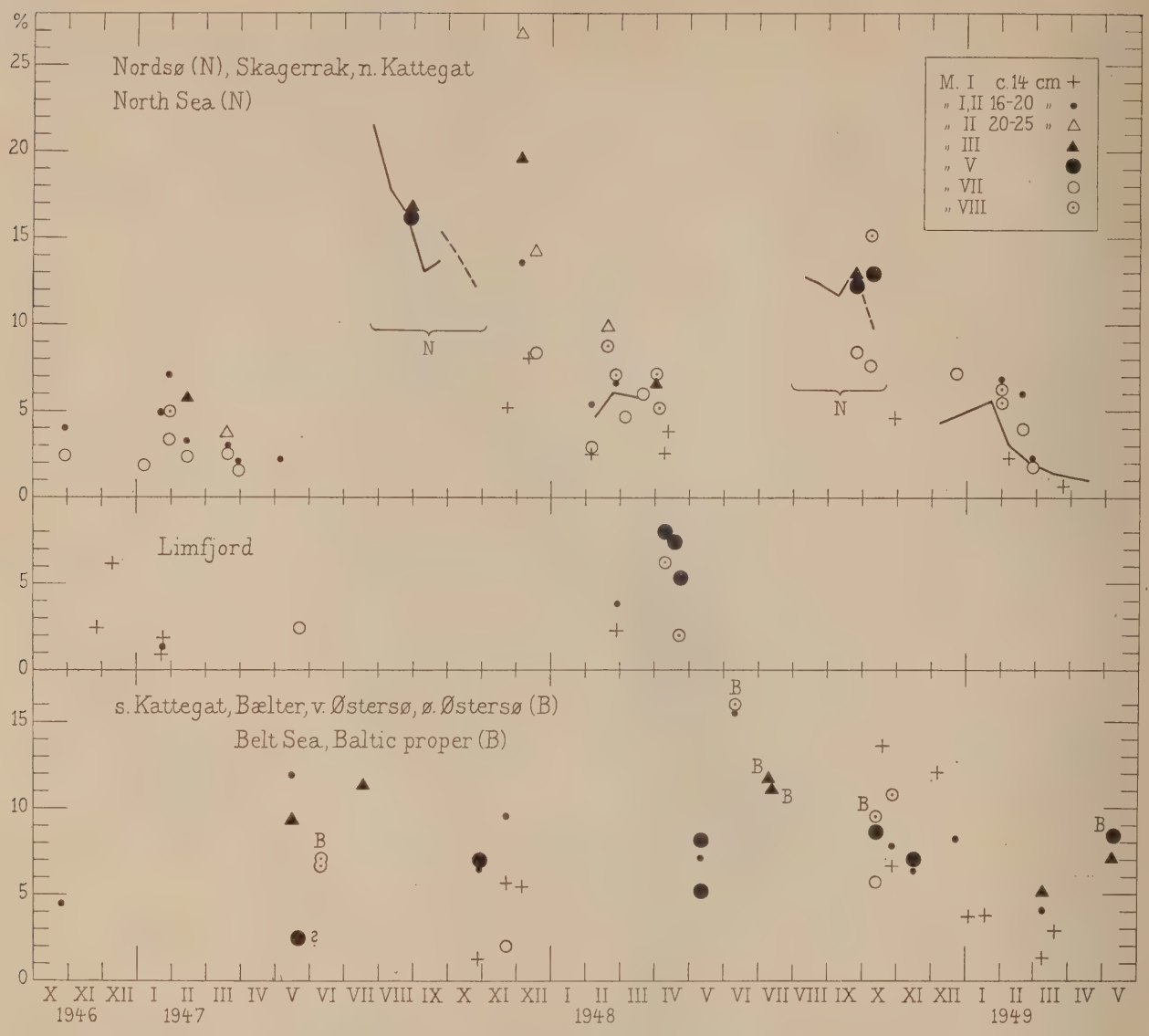
%
Nordsø (N), Skagerrak, n. Kattegat
North Sea (N)
M. I c. 14 cm +
» I,II 16-20 » •
» II 20-25 » △
» III ▲
» V ●
» VII ○
» VIII ⊙
N
N
Limfjord
s. Kattegat, Bælter, v. Østersø, ø. Østersø (B)
Belt Sea, Baltic proper (B)
B
X XI XII I II III IV V VI VII VIII IX X XI XII I II III IV V VI VII VIII IX X XI XII I II III IV V
1946
1947
1948
1949

Figure 4. Fat-contents of the herring. The samples with statements of maturity mainly originate from the samples examined by the Biological Station; the percentages joined by stright line date from the samples sent to Fiskeriministeriets Forsøgslaboratorium from the fishing harbour. In the North Sea samples: Full lines: N. of lat. 57° N., dashed lines: S. of lat. 57° N.

Beside the samples of big herring, the fat-contents of which are given in table 7, a sample from February 1948 consisting of about 13 cm. long, small herring (industrial fish) was sent to Fiskeriministeriets Forsøgslaboratorium. The fat-content of these fish was 2.8 %.

The great majority of herring included in table 7 were spent fish of 20—25 cm. length. The mean values for spent herring in samples consisting exclusively of such fish and for small herring are plotted in figure 4.

The fat-content at different stages of maturity.

It appears from table 4 and figure 4 that the fat-content of the small herring of less than 16 cm. length differs very much from one catch to the other. In some cases it was very low, for instance about 1 % in a sample from the Limfjord, Jan. 1947; in a sample from the southern Kattegat (Hundested), Oct. 1947; and a sample from Læsø Rende, Mar. 1949; but in several samples it was 6 % or more, in some catches from Kerteminde (Great Belt) in

Oct.—Dec. 1948 even above 12 %. It may be very different in catches taken at the same time and in nearly the same locality. In small herring caught in the Limfjord at Fur on 26. Nov., 1946 there were 2.4 % of fat, but in herring from the Risgaard Broad on 9. Dec. 6.1 %. The herring of the two catches were of the same size and belonged to the same race. In two samples of small herring from 1947, collected in nearly the same locality S.S.E. of Skagen (the Scaw) on 18. Nov. and 9. Dec., the fat-contents were found to be 5.2 and 8.1 %, respectively. The herring of both of these samples were summer or autumn spawners from the North Sea with exactly the same racial character.

The herring of 16—20 cm. are generally somewhat fatter than the small herring. In the Belts and the Baltic they are mostly fat herring (mattie) of maturity II—III at this size. In the catches examined the highest fat-contents of these herring were found at Assens (Lesser Belt) in May 1947 (12 %) and at Bornholm in June 1947 (16 %). In several cases they had only c. 5 % of fat. In the Skagerrak most herring do not reach the fat herring stage until they have a length of a little more than 20 cm. though a percentage of 14 was observed in one sample of 20 cm. long herring from Dec. 1947. In the same catch the slightly bigger herring, showing a maturity of II—III, had the highest fat-content observed during these investigations, 27 %, and in the herring approaching the half-herring stage there were 20 % of fat.

In herring fillets with skin on Lovern and Wood (l. cit.) found that the fat-content in 18—27 cm long herring of maturity I (international scale), which had been caught at the east coast of Scotland in Jan.—July, varied between 5 and 18 %.

In the areas between Bornholm and the Skagerrak the full herring showed fat percentages between 5 and 13. In the North Sea 16 % occurred in one of the catches examined; in fillets of summer herring of maturity V—VI (full herring on the point of spawning) from the western North Sea Lovern and Wood in 1935—36 found 14—17 % of fat and in the corresponding spring herring from Scotland in 1935—37 3—16 %.

Wimpenny in 1934 found similar values in muscles of herring taken in the fishery at eastern England, but in some cases the percentages amounted to 20 and 30. On 1. June, 1935 the mean of 10 herring was 19.4 %, on 14.—15. June, 1935 it was 12.3 %. In July—Sep. 1935 and in July—Nov., 1937 the fat-content of the muscles of these herring from eastern England was as high as 30—40 % (Wimpenny, l. cit.).

The Norwegian winter herring (mostly full herring) in 1937—41 before 31. Jan., between 1. and 14. Feb. and after 15. Feb. showed fat percentage of 12.9, 11.2 and 10.2 %, respectively[1]).

As known the spent herring is mostly lean and generally has only 2—4 % of fat though it may show 7—8 %. In 22—24 cm. long, spent herring caught on 3. April, 1949 W.N.W. of Hirtshals Fiskeriministeriets Forsøgslaboratorium found only 0.1 % of fat.

At the time when the sexual organs recover their compact shape the fat-content generally rises though in a few cases it may be as low as 2 % at maturity VIII. The highest fat-contents, 15—16 %, in herring of this maturity were found at Bornholm and in the North Sea.

As was the case with the coefficient of nutrition the fat-content was examined in some samples of sprat caught together with small herring, in one catch from the Skagerrak on 28. Feb., 1949, however, together with big herring only.

The following table gives the results of these fat analyses.

		Sprat		Herring	
		cm.	% of fat	cm	% of fat
Hirtshals	25.3.47.....	11–15	2.0	15–20	2.1
The Scaw	9.12.47.....	ca. 13	20.7	ca. 13	8.1
—	4.2.48.....	6– 9	3.0	10–15	2.5
—	—	13–14	10.5	..	..
—	26.10.48.....	10–13	11.1	ca. 12	4.6
—	28.2.49.....	14–16	6.3	..	..
The Limfjord	9.12.46.....	ca. 8	7.0	ca. 12	6.0
—	—	ca. 14	16.7	..	..
—	21.1.47.....	10–15	6.1	9–10	0.8
—	—	..	..	13	1.8
Hundested	7.3.49.....	14–16	3.8	..	..
Kerteminde	17.3.49.....	8	4.7	10–14	2.8
—	—	15	11.5	..	..

In all cases, perhaps with the exception of one catch from off Hirtshals on 25. Mar., 1947, the sprat thus showed a constantly higher fat-content than the herring of the same length.

[1]) Årsberetn. Norges Fiskerier 1943.

Table 8. The fat-content at different stages of maturity in the individual quarters of the year. Mean figures and lowest and highest percentages. Numbers of samples in brackets.

Maturity	Season	4. quarter mean	4. quarter from—to	1. quarter mean	1. quarter from—to
Skagerrak, northern Kattegat.					
I, below 16 cm	1946–47	6.7 (2)	5.2– 8.1	3.0 (3)	2.5–4.0
	1947–48	4.6 (1)	..	1.5 (2)	0.7–2.3
II, III	1946–47	4.0 (1)	..	4.3 (8)	2.1–7.1
	1947–48	18.2 (3)	13.2–26.9	7.3 (3)	5.4–9.9
VII, VIII	1946–47	2.4 (1)	..	2.4 (5)	1.6–3.4
	1947–48	8.3 (1)	..	6.3 (3)	2.7–8.9
	1948–49	7.3 (1)	..	4.5 (4)	1.8–6.5
Southern Kattegat, Belts, Baltic.					
I, below 16 cm	1948–49	10.7 (3)	6.6–13.6	2.9 (4)	1.3–3.7
		2. quarter	3. quarter	4. quarter	1. quarter
II, III	1946–47	..	..	4.5 (1)	..
	1947–48	10.6 (2)	11.3 (1)	8.0 (2)	..
	1948–49	7.1 (1)	11.7 (1)	7.5 (3)	4.6 (2)

The seasonal change of the fat-content at the same stage of maturity.

As a matter of course the fat-content at a certain stage of maturity must vary in the course of the year in the same way as the coefficient of nutrition.

The variations of the fat-content from year to year are so great, that we must content ourselves with comparing it within limited, short periods instead of comparing the means of several years as we did in table 2 and figure 2 for the coefficient of nutrition. The material in itself is rather small for such an examination, thus getting even more scattered. For several maturities, moreover, fat determinations are lacking from April to September. As will appear from table 8 the fat-content like the coefficient of nutrition at the different stages of maturity decreases from autumn to winter, the widest variation occurring in the immature, small herring and the herring approaching maturity. In the herring approaching maturity in the southern Kattegat, the Belt Sea and the Baltic we can follow the variation through a couple of years and, as might be expected, we find the highest fat-contents in summer.

Differences in the annual variations in herring spawing at different seasons.

The fat-content must of course show a different seasonal variation in adult herring spawning in spring and in autumn. In spring and early summer when it is lean and spent the quality of the spring spawner is naturally inferior to that of the autumn spawner, which at this time is re-maturing. When the autumn herring has spawned (about Sep.—Oct.) it is lean and inferior to the spring spawner. The fact, however, that the autumn herring of the inner Danish waters has grown very rare during recent years when the fat analyses were carried out prevents us from directly following this difference. For the comparatively rare spring herring (or winter herring) of the Skagerrak we only have determinations of fat-content from samples of immature herring. Such herring, for instance, of 18—20 cm. length, taken off Hirtshals on 23. and 27. Jan. and 13. Feb., 1947, showed fat percentages of 5.9, 7.1 and 3.0, respectively. From the first of these samples the herring were autumn spawners from the western Northern Sea; from the second sample they were

Table 9. Fat-contents (in %) in the herring from the western North Sea. From Lovern and Wood.

	Spring herring	Summer herring		Spring herring	Summer herring	Autumn herring
Jan.	11	..	July	..	18	22
Feb.	8–4	..	Aug.	..	15–11	16
March	2	..	Sept.	19[1])	10	14
April	..	2	Oct.	14	8	14
May	..	5	Nov.	14	6	14–?
June	..	15	Dec.	16	3	..

[1]) Herring from the east coast of Scotland.

autumn spawners from the northern, deep Kattegat (Kobbergrund herring); from the last sample they were spring herring from the northern, deep Kattegat (also termed winter spawners) or spring herring from the Norwegian coast of the Skagerrak.

In two samples from the same area the immature herring of about 20 cm. length on 18. Feb., 1949 had a fat-content of 6.0 % and belonged to the said spring spawners while the herring of the same length and maturity on 28. Feb. showed 2.3 % fat and were autumn spawners from the western North Sea. The spent herring in both of these samples were autumn spawners from the western North Sea, which showed fat-contents of 4.0 and 1.8 %, respectively.

In other words the fat-content of immature young herring in Jan.—Feb. was higher in the spring herring than in the autumn herring in one case and lower in another, and so we cannot say about these herring that one is always or generally fatter than the other.

However, it is possible to follow the annual variation in the adult herring at varying stages of maturity in the very comprehensive investigations carried out in Scotland in 1935—37 by Lovern and Wood. They found the annual variation, (expressed in their tables and figure 1) shown in table 9.

It is seen that the summer spawners from the end of August to the beginning of January contained much less fat than the spring spawners. Besides this we notice the enormous rise from April to July in the summer spawners. The spring spawners and autumn spawners must show a corresponding rise at this season.

The two figures for spring herring in February, for summer herring in August and for autumn herring in November stand for the fat content before and after the spawning.

The seasonal variation of the fat-content in the catches.

As far as the North Sea fishery and the Skagerrak fishery for adult herring (food fish) are concerned the changes in the quality of the herring caught during the fishing season appear distinctly from the extensive fat analyses of samples sent to Fiskeriministeriets Forsøgslaboratorium. The mean figures for these samples are shown in figure 4. It also appears from the figure that the average fat-content of the catch at the time being is a mean value for the sometimes very different fat-contents found in the herring at different stages of maturity contained in the catch.

The Danish herring fishery in the North Sea in the main goes on within a zone of 2—4 degrees in width and reaching from about lat. 60° N. to lat. 55° N., i. e. from the Viking Bank westwards nearly to the Shetland Isles and down to the Dogger Bank. The southward shifting of the catching localities during the season appears from table 5. At the beginning of the season on Fladen Ground considerable quantities of immature herring are found in the catches. Racial investigations have shown that these herring are spring spawners from the north of Scotland spawning about February while the full herring constituting the majority of the catches are summer and autumn spawners from the western North Sea.

The rapid decrease of the fat-content from July to August is due to the fact that the immature fat herring in the northernmost areas grow comparatively rarer in the catches. The decrease from August to October is caused by the following facts: that there is a continuous decrease of the percentage of immature herring; that the spent herring constantly grow more numerous; and that the fat content of the full herring decreases during the time immediately before the spawning.

It is seen that the fat-content of the herring caught in the Fladen Ground area, from which locality we have analyses from the end of July to October, in 1947 decreased very much during the period, from more than 20 to 12 %; in 1948 the herring was comparatively lean in summer, and the fat-content therefore fell from 12.5 to 10 % only.

As will appear from figure 4 the inferiority of the fat-content in the summer of 1948 to that of 1947 to some extent only follows from the fact that the spent herring in 1948 constituted a greater part of the catches than in 1947; the principal cause was that the herring on the whole was leaner.

A prominent feature in the Skagerrak is that in each of the winters 1947—48 and 1948—49 there is a conspicuous fall of the fat-content, particularly in the young herring caught for processing, but also in the spent herring. We find a corresponding decrease of the fat-content of the small herring of about 15 cm. in the Belt Sea from Oct. 1948 to Jan. 1949 and in the Limfjord from Nov.—Dec. 1946 to Jan. 1947.

Variations of the fat-content from year to year and their causes.

At the same stage of maturity there are very wide variations from year to year as will appear from figure 4. In the Skagerrak the bigger herring were very lean in the winter of 1946—47, but much fatter in the winter of 1947—48; in the Belt Sea both small and big herring were much leaner in the autumn of 1947 than in the autumn of 1948. It appears from the figure that in the Skagerrak the variations from year to year in the fat-content of the herring during the two years in which investigations were carried out in both waters have followed the variations of the fat-content in the North Sea. This is quite natural because most of the herring caught in the Skagerrak in autumn and winter belong to the same race as those caught in summer and autumn in the northwestern North Sea. This is true both of the young herring and of the bigger herring that have entered the Skagerrak in autumn, part of them as young herring at the fat herring stage, but most of them after they have spawned in the North Sea.

The variations in the quality of the small and of the big herring in the Skagerrak and the northern Kattegat cannot be expected to coincide every year because these two groups live in different places—the small herring mostly in quite shallow water, the big ones in deeper water—and because they feed on a different diet. It may therefore be supposed that there is no or at any rate only an inconsiderable correspondence between the variations from year to year in the fat-content of the herring in the North Sea and of the small herring in the Skagerrak and the northern Kattegat.

As might be expected the variations from year to year in the fat-content of the big herring run parallel to the variations in the coefficient of nutrition in these herring.

It is no doubt possible to a considerable extent to foretell the fat-content of the bigger herring caught in the Skagerrak in autumn and winter from that of the North Sea herring during the previous season. However, a complete accordance cannot be expected except at the beginning of the season because the fat-content of the Skagerrak herring will also depend on the quality and, perhaps, on the amount of the food available in the Skagerrak, particularly the big euphausids.

On the variations from year to year in the fat-content of the herring caught in the North Sea in summer and autumn there are some investigations by Wimpenny (l. cit.) from the English east coast fishery in 1934, 35 and 37, and by Lovern and Wood (l. cit.) from the Scottish east coast fishery and the Fladen Ground fishery in 1935—36. The fat-content of the Fladen Ground herring in these years was practically the same as in 1947.

In herring at the same stage of maturity the variations from year to year in the fat-content must primarily be due to variations in quality and amount of the food of the herring. Wimpenny (l. cit., p. 342) has called attention to the fact that the fat-content of the herring reaches its maximum in August, about one month later than the fat-content of the plankton.

As mentioned above the production of plankton mainly depends on the arrival of phosphates and nitrates (see p. 9) from the deeper water layers. These layers have a higher salinity than the upper water layers, and so a high salinity of the surface layers within a certain area of the North Sea or in our inner waters will be indicative of an increased supply of nutritary salts.

For the fishery of the east of England we are able to compare the variations in the fat-content of the herring with the variations of salinity within the area Dogger Bank and northwards between eastern longitudes 1° and 4° and lat.s 53.30° and 54° N. and between eastern longitudes 1° and 5° and lat.s 54° and 56° N. Mag. J. Smed has most kindly informed me of the mean deviations from the normal of the salinities for this area. They are found in table 10 together with the mean fat-contents of the herring in Wimpenny's samples from the fishery of eastern England.

Table 10. Anomalies of salinity in $^0/_{00}$ (see the text) and the fat-contents of the herring in the fishery of eastern England.

	Anomaly of salinity				Fat-content of the herring in $^0/_0$	
	Feb.	March	Apr.	May	Oct.	Nov.
1934.....	0.04	0.03	0.04	0.07	ca. 18	ca. 12
1935.....	0.08	0.09	0.10	0.13	- 36	- 30
1937.....	0.00	÷ 0.05	÷ 0.04	÷ 0.04	- 30	- 30

For the Fladen Ground area the corresponding mean salinities in the area between long.s 1° W. and 1° E. and lat.s 58° and 60° N. according to mag. Smed are shown in table 11 together with the mean values of the fat-content of the herring from the

Table 11. Salinity in the Fladen Ground area and the fat-content of the herring in this area.

	Salinity, ‰		Fat-content of the herring in %		
	April	May	Mat. III July	IV-V July-Aug.	VII Nov.
1935.....	35.24	35.26	16.4	14.5	6.0
1936.....	35.26	35.31	17.1	16.6	7.2

Scottish investigations[1]). Unfortunately there are only observations of salinity from April and May of both years.

In other words the variation of salinity in 1935—36 corresponds to the variations of the fat-content. For 1947—48 dr. N. G. Jerlov, Oceanografisk Institut, Gothenburg, has most kindly provided me with Swedish observations of salinity between 0° and 2° E. longitudes at about lat. 56°30′ N. on 6-9/5 1947 and 5-8/5 48, and mag. J. Smed, hydrographer of the International Sea Investigations, has further submitted to me other observations from the same area on 21/5 1947 (Danish observations) and 24-25/4 1948 (English observations). According to these the mean salinities (‰) were:

[1]) Lovern and Wood: l. cit. Table IV, p. 286.

		n. lat.	at 0 m.	at bottom
6-9/5	1947.....	ca. 56°32′	35.05	35.10
21/5	—	ca. 56°30′	35.07	35.13
24-25/4	1948.....	ca. 56°10′	34.80	34.84
5-8/5	—	ca. 56°30′	34.97	35.02

Corresponding to the stronger influx of saline water in 1947 than in 1948 the fat contents of the herring was higher in 1947 than in 1948.

It must be noted that dr. J. Eggvin most kindly has informed me that the salinity between the same degrees of latitude but a little more to the north at ca. 57°40′ on the 27-28/5 1947 was 34.81 ‰ at the surface and 34.98 ‰ at the bottom. Though the strong influx of water with high salinity came to an end rather soon it must have played a perceptible rôle for the nutritive conditions of the North Sea.

In the inner Danish waters the variation from year to year in the fat-content of the herring is the same as the variation in the coefficient of nutrition, for which we have a material from several years, and for which a distinct dependence on the hydrographical conditions during the previous time has been demonstrated to exist (see fig. 3). This dependence seems to be so great, that forecasts on the quality of the herring can be based on it.

Amount and Growth of Herring Fry in the Danish Waters.

By

AAGE J. C. JENSEN

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The material.

The occurrence and amount of herring larvae, i. e. of the recently hatched, tiny herring fry, which have not yet got any scales, and which drift along with the current without any independent power of moving from one locality to the other, have been examined by the Danish Biological Station since the nineties and by Kommissionen for Havundersøgelser (Kommissionen for Danmarks Fiskeri- og Havundersøgelser) since 1904. In the beginning only plankton nets with gauze were used, mostly in vertical hauls. The amount of fry caught in this way is very small, and therefore investigations of this kind are not very illustrative of occurrence and quantity of the larvae. However, sufficient catches can be made with C. G. Joh. Petersen's young-fish-trawl, which was used for fishing in the upper water from 1903. This gear consists of a 5 m. long stramin bag with square opening, the sides of which are spread by means of sticks of 1.26 m. height and where the head and foot ropes are 2.5 m. long[1]). During the haul the ropes form a backward bend; the width of the fishing gear therefore decreases to about 2.2 m., which gives an opening of 2.75 m^2. Later on the Biological Station, at any rate for some years, used a young-fish-trawl with only 1 m. high sticks and 2 m. long ropes, giving an opening of $^2/_3$ the original one. In 1912 Kommissionen, at any rate partially, changed to a 2 m. ring-trawl as the standard gear, that is to say a 7 m. long stramin bag distended by an iron ring with a diameter of 2 m., in other words with an opening of 3.14 m^2. In the autumn of 1926 the 2 m. ring-trawl was introduced as the standard gear of the Biological Station. For the rest the two gears seem to be equally good; the young-fish-trawl has the advantage that it may be used "on blocks", i. e. with sticks lengthened downwards below the gear for fishing quite near the bottom where the largest numbers of larvae are often found.

[1]) Described in Johs. Schmidt: Fiskeriundersøgelser ved Island og Færøerne i Sommeren 1903. Skrifter udg. af Kommissionen for Havundersøgelser Nr. 1. 1904.

Down to 1926 the Biological Station in most years examined the quantities of larvae, but as a rule the larval herring were not measured though in some cases their smallest and greatest lengths were stated, and in many cases their number is only given as "many" or "few".

From Kommissionen fishing experiments with the young-fish-trawl or ring-trawl were carried out in February-March 1904 and in March-April 1905 and 1906 in the eastern North Sea and the Skagerrak, in March-April 1907 in the Skagerrak, the Kattegat, the Sound and the Belts, in April 1908 and 1909 in the Kattegat, in May-July 1911 in the Kattegat, the Great Belt and the western Baltic, in May 1912 in the Belts and the western Baltic, in Oct. 1922 in the eastern North Sea, the Skagerrak and the Kattegat, in April-May 1923 in the Skagerrak, the Kattegat, the Sound, the Belts and the western Baltic, in April 1925 in the eastern North Sea, the Skagerrak, the Kattegat, the Sound and the Baltic, in Oct. 1925 in the eastern North Sea, the Skagerrak, the Kattegat, the Sound and the Baltic, in Oct. 1926 and March-April 1927 in the eastern North Sea, the Skagerrak, the Kattegat and the Sound, in Sep.-Oct. the Skagerrak and the Kattegat and in April 1932 in the eastern North Sea, the Skagerrak and the Kattegat. In most of these investigations the herring larvae were measured, but in many cases the number of hauls is too small to show the amount of larvae.

A table on catches of sprat and herring larvae (not separated) made in 1903—04 by the Biological Station and Kommissionen were published by Andreas Otterstrøm[1]). The catches from Kommissionen in Nov. 1903—06 and in Sep.-Oct. 1922 were given by A. C. Johansen[2]) in his figure 1 and 2, p. 28 and 29 and catches during the spring months of 1904, 05, 06, 07 and 23 in his figure 4, p. 31; in his table 5,

[1]) Andreas Otterstrøm: Eggs and Young of Fishes in the Danish Waters. Rep. Dan. Biol. Stat. XIII, 1906.

[2]) A. C. Johansen: On the Summer and Autumn-spawning herring of the North Sea. Medd. f. Komm. f. Havundersøgelser. Ser. Fiskeri. Bd. VII, 5. 1924.

Table 1. Numbers of stations with the ring-trawl in March-August 1927—39 (see map fig. 1).

Area:	Northwest-Kattegat	Round Anholt	At Djursland–Samsøbelt	N. of Sjælland	Great Belt	Lesser Belt W. Baltic	The Sound and southwards	Bornholm	The Limfjord	Total
March	..	..	8	..	10	3	..	..	..	21
April	21	47	135	80	121	78	91	..	21	594
May	24	33	88	17	72	72	47	..	39	392
June	2	3	27	3	26	24	..	5	..	90
July	1	..	5	..	7	..	5	16	..	34
August	..	..	..	..	1	..	1	..	..	2

p. 33 there is a list of the stations at which herring larvae were caught in the Jyske Rev area in the autumn of 1922, in table 8, pp. 36—37 a corresponding list of catches in the springs of 1904—23.

Tables on the numbers of larvae caught in the Skagerrak and the Kattegat in the springs of 1903, 04, 06, 08, 09 and 11 are given by A. C. Johansen[1]).

The numbers of herring larvae caught at stations in the Kattegat in the autumns of 1925, 26 and 30 are illustrated by E. M. Poulsen[2]) in his figs. 5—10, pp. 10—12 and in the North Sea and the Skagerrak in his figs. 1—2, p. 4; a list of the catches at the stations in 1930 is found in his table I, p. 16.

Maps illustrating the total numbers of larvae and the numbers of 5—9 mm. length (for 1927 only those of 5—9 mm.) are found in the following volumes of Rapports et Procès-Verbaux:

1927	vol.	49, p. 155
1928	-	60, p. 125, 126
1929	-	66, p. 146, 147
1930	-	74, p. 185, 186
1931	-	81, p. 216, 217
1932	-	85,2, p. 54, 55
1933	-	89,2, p. 54, 55
1934	-	94,2, p. 46, 47
1935	-	100,2, p. 70, 71
1936	-	105,2, p. 54, 55
1937	-	107,2, p. 60, 61

Where the depth at a station is more than about 20 m. hauls were often, more particularly during recent years, made separately at different depths, but in several years the hauls at the different depths were made continuously, so that for instance after 15 minutes' hauling the towing line was shortened. When several hauls were made separately at one station the figure used here represents the mean value of the catches of the individual hauls.

The herring larvae that drift with the current are found in the water round the spawning places in much the same way as the smoke above a fire, but in most cases even more irregularly distributed, partly because the direction and force of the currents shift incessantly, partly because the larvae by night rise in the water while by day they gather near the bottom. This up- and downward movement was examined in detail by A. C. Johansen[1]). It also has the effect that the catches by night are much heavier than by day. The present investigations are mainly based on the researches of the Biological Station in 1927—39, all of which were made by day.

In some localities the currents will collect the objects that are drifting in the water; this is particularly the case at the edges of current as will often be seen on the surface of the sea. That is why a haul in November 1932 in the channel NW. of Sejrø gave 2 142 herring larvae in 30 minutes in the lower water layer and only 18 in the upper layer; in comparatively closely situated areas, S. of Schultz's Grund and off the Kalundborg Fjord corresponding hauls of 30 minutes gave 112 and 4 larvae, and 124 and 52 larvae, respectively. Between Nyborg and the north of Langeland 30 minutes' hauls in 1928 gave 256, 5 286, 104 and 3 486 larvae.

On account of the irregular occurrence it is necessary to make many hauls if we want to obtain a reliable mean figure for the amount of larvae within an area.

[1]) A. C. Johansen: Über die Winterheringe des Kattegats. Wissensch. Meeresuntersuch. N.F. Abt. Helgoland XV, 12. 1923.

[2]) E. M. Poulsen: On the Spawning Places of the Herring in certain Parts of the North Sea, the Skagerrak, and the Kattegat in the Autumn of 1930 and some earlier years. Medd. f. Komm. f. Havunders. Ser. Fiskeri IX, 4, 1931.

[1]) A. C. Johansen: On the diurnal vertical Movements of Young of some Fishes in Danish Waters. Medd. f. Komm. f. Havunders. Ser. Fiskeri. VIII, 1. 1925.

Figure 1. Schematic localization of spawning places of winter and spring herring together with the division of waters used here. Hatched areas: winter spawners; spawning places of the coastal winter herring of the Belt Sea are no doubt found in more places than those given here. Black fields: spring herring. Spawning places of spring herring playing a part in the Danish fishery are further found at the coast of Scotland, at the southwestern and southern coast of Norway and in many localities at the coasts of the Baltic E. and N. of Rügen-Schonen (not at Bornholm) and perhaps on Davids Banke, N. of Bornholm. On the races of herring see p. 32.

Table 2. Mean numbers of herring larvae below 9, of 10—22, and above 23 mm. length, caught per 5 hours in the 2 m. ring-trawl within the areas a—g. Numbers of stations in italics. Each station calculated per 30 minutes.

	N. W. Kattegat a				Round Anholt b				W. of Djursland-Samsø Belt c				N. of Sjælland d				Great Belt e				Lesser Belt-western Baltic f				The Sound and southwards g			
	–9	10–22	23–	st.	–9	10–22	23–	st.	–9	10–22	23–	st.	–9	10–22	23–	st.	–9	10–22	23–	st.	–9	10–22	23–	st.	–9	10–22	23–	st.
A. *April.*																												
1927[1])	0	5	0	*2*	224	44	5	*5*	0	33	0	*7*	30	25	..	*2*	0	94	2	*5*	0	11	0	*7*	5	5	..	*1*
1928	..	..	..	*0*	..	..	..	*0*	..	..	..	*0*	..	..	..	*0*	..	..	..	*0*	..	..	..	*0*	..	..	..	*0*
1929	..	..	..	*0*	..	..	..	*0*	0	2	0	*8*	0	9	0	*16*	0	0	0	*9*	0	0	0	*4*	4	8	0	*5*
1930	0	27	0	*6*	6	7	0	*10*	1	98	0	*14*	0	130	8	*4*	0	22	2	*26*	0	2	0	*12*	0	0	0	*8*
1931	..	..	..	*0*	..	..	..	*0*	0	79	2	*10*	0	36	5	*4*	1	38	4	*12*	0	10	4	*9*	0	70	0	*2*
1932	0	80	0	*2*	..	..	..	*0*	0	29	0	*9*	0	0	0	*4*	0	19	1	*9*	0	4	6	*6*	0	2	0	*18*
1933	0	10	0	*3*	..	..	..	*0*	2	12	0	*6*	5	56	0	*8*	0	20	0	*6*	..	..	..	*0*	0	4	0	*16*
1934	0	481	33	*7*	10	42	2	*4*	1	192	3	*12*	11	53	0	*7*	0	0	0	*1*	..	..	..	*0*	0	5	0	*5*
1935	..	..	..	*0*	70	45	0	*8*	2	9	0	*17*	6	17	0	*10*	0	11	0	*12*	0	2	0	*13*	0	4	0	*4*
1936	..	..	..	*0*	17	105	0	*8*	2	4	7	*16*	2	35	0	*6*	0	14	0	*18*	0	9	0	*9*	0	10	0	*11*
1937	..	..	..	*0*	24	224	3	*10*	8	138	0	*10*	20	372	0	*9*	1	17	0	*15*	0	33	1	*6*	0	22	1	*10*
1938	0	0	0	*1*	0	25	0	*7*	3	72	0	*14*	0	30	0	*6*	48	10	0	*16*	0	60	0	*5*	0	7	0	*7*
1939	..	..	..	*0*	..	..	..	*0*	15	95	0	*13*	14	116	0	*5*	15	5	0	*3*	21	17	0	*7*	24	178	3	*5*
B. *May.*																												
1927	0	27	0	*3*	5	5	0	*2*	0	5	0	*1*	..	..	..	*0*	0	0	0	*1*	..	..	..	*0*	..	..	..	*0*
1928	..	..	..	*0*	..	..	..	*0*	5	2	0	*4*	..	..	..	*0*	0	3	0	*3*	..	..	..	*0*	..	..	..	*0*
1929	0	5	0	*8*	6	20	0	*9*	42	16	0	*20*	..	..	..	*0*	153	79	0	*31*	7	5	0	*26*	..	..	..	*9*
1930	2	28	2	*10*	6	3	0	*11*	1	1	0	*17*	..	..	..	*0*	0	0	0	*7*	..	..	..	*0*	..	..	..	*0*
1931	..	..	..	*0*	3	0	0	*4*	..	..	..	*0*	0	0	0	*2*	..	..	..	*0*	..	..	..	*0*	0	8	0	*7*
1932	0	0	0	*4*	0	2	0	*4*	0	0	0	*2*	..	..	..	*0*	..	..	..	*0*	..	..	..	*0*	..	..	..	*0*
1933	..	..	..	*0*	0	20	0	*2*	0	3	0	*10*	0	0	0	*1*	0	3	0	*7*	0	0	0	*12*	..	..	..	*0*
1934	0	410	200	*1*	..	..	..	..	4	4	0	*2*	..	..	..	*0*	3	2	0	*6*	0	0	0	*5*	..	..	..	*0*
1935	0	0	0	*1*	..	..	..	..	0	2	0	*4*	..	..	..	*0*	0	0	0	*2*	..	..	..	*0*	0	12	0	*11*
1936	..	..	..	*0*	..	..	..	..	0	6	0	*7*	..	..	..	*0*	0	3	0	*3*	..	..	..	*0*	..	..	..	*0*
1937	..	..	..	*0*	..	..	..	..	4	34	0	*8*	20	52	0	*10*	0	0	0	*3*	..	..	..	*0*	..	..	..	*0*
1938	..	..	..	*0*	..	..	..	..	2	2	0	*10*	193	110	0	*3*	15	0	0	*2*	0	0	0	*14*	1	0	0	*12*
1939	..	..	..	*0*	0	0	0	*5*	3	6	0	*5*	0	15	0	*1*	0	13	1	*11*	16	7	0	*15*	0	0	1	*12*

C. *March and june, july and august.*

Year	Area	–9	10–22	23–	st.	Year	Area	–9	10–22	23–	st.	Year	Area	–9	10–22	23–	st.
March						June						July					
1927.....	c	78	155	0	*8*	1929.....	c	5	9	0	*13*	1929.....	e	0	0	0	*7*
—	e	0	82	2	*8*	—	e	0	10	0	*3*	—	g	0	0	0	*2*
—	f	0	10	0	*1*	1930.....	c	0	1	0	*10*	1930.....	g	0	0	0	*2*
1931.....	f	0	0	40	*2*	—	e	8	2	0	*15*	1934.....	a	0	20	0	*1*
June						—	f	0	0	0	*15*	—	c	0	36	0	*5*
1927.....	c	0	5	0	*1*	1931.....	b	0	7	0	*3*	—	g	0	0	0	*1*
—	e	0	5	0	*1*	1932.....	f	0	0	0	*1*	1938.....	c	0	0	0	*1*
1928.....	a	0	5	0	*2*	1934.....	c	0	5	0	*2*	August					
—	c	20	0	0	*2*	1935.....	d	0	0	0	*3*	1932.....	e	0	0	0	*1*
—	e	37	3	0	*7*	—	f	0	0	0	*1*	1934.....	e	0	0	10	*1*
—	f	45	6	0	*8*							—	g	0	0	0	*1*

[1]) In b, d og g fra S/S "Dana",

Tabie 3. Mean numbers of herring larvae caught per 5 hours with the 2 m ring-trawl in the Limfjord.

	April				May			
mm.:	–9	10–22	23–	st.	–9	10–22	23–	st.
1927	92	2	2	*4*	12	0	2	*4*
1930	..	..	..	..	12	10	0	*8*
1932	..	..	..	..	0	0	0	*20*
1933	0	0	0	*6*	..	..	..	*0*
1934	1	18	0	*11*	15	22	0	*7*

Table 4. Mean numbers of herring larvae caught per 5 hours with the 2 m ring-trawl at Bornholm.

	June				July			
mm.:	–9	10–22	23–	st,	–9	10–22	23–	st.
1932	..	..	..	..	0	30	0	*4*
1935	0	0	2	*5*	..	..	..	..
1936	..	..	..	..	0	2	0	*3*
1939	..	..	..	..	0	1	0	*9*

Herring larvae in spring and early summer.

Hauls with the ring-trawl in 1927—39 were made from March to August, most of them in April-May (see table 1). In many cases the number of hauls is too small to give an exact picture of the average amount of larvae.

The distribution of herring larvae in the waters in spring.

A survey of the amounts of herring larvae taken within the different areas in 1927—39 is found in tables 2, 3 and 4 where the larvae are divided into 3 length groups.

A detailed examination of the length distribution of the herring larvae (tables I—VII) will show that there are several different groups, the mean lengths of which increase in the course of spring, but which in many cases disappear from the catches before they reach a mean length of 20 mm.

During the former half of April of most years we find only one length group, the mean length of which ranges between 12 and 18 mm., but during the latter half of April, in 1935 (and in 1926) in the areas b and d already from the beginning of the month, in May and June we find another group, the mean length of which is below 10 mm. in many catches throughout the period, but which in other catches, particularly during the latter half of May and in June, reaches a mean length of 10—15 mm. in a few catches from June of even more than 15 mm. Especially in May this occurrence of several length groups, which in many cases overlap, makes it difficult or impossible to distinguish between them if we take the length distribution for one area even within the short period of a fortnight. We cannot differentiate them until we have examined the growth of the larvae.

The Growth of the herring fry. Distinction between larvae of winter herring, spring herring and autumn herring.

In figure 2 a comparison is made between the cases in which it has been possible to follow the growth of the larvae because the fishing experiments were repeated within the same area at intervals ranging between a fortnight and a month. Figure 3 gives the results of German investigations on the growth of the larvae and the tiny young fish stage in the western Baltic; the figure illustrates measurings of larval and young fish stages in Slien carried out by H. A. Meyer in 1874, in 1876 of larval herring from Slien, kept in a container suspended in the Kiel Bay, and in 1875 of young herring which in the Kiel

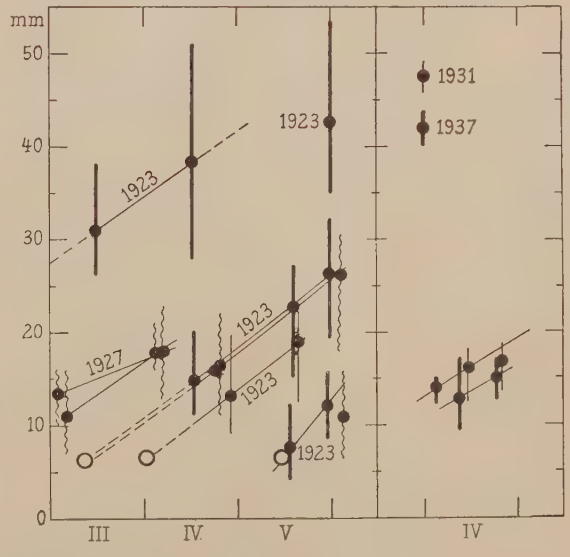

Figure 2. Growth of herring larvae in the Kattegat, the Belt Sea and the Sound in March—May. The vertical lines represent the length distribution of the larvae (thin lines: the Kattegat; heavy lines: the Belt Sea; wave lines: the Sound); ● denote their mean lengths, the oblique lines show changes of length (growth) when the fishery was repeated within the same area at intervals of some time. ⊙ denote the approximate spawning date found by extrapolation.

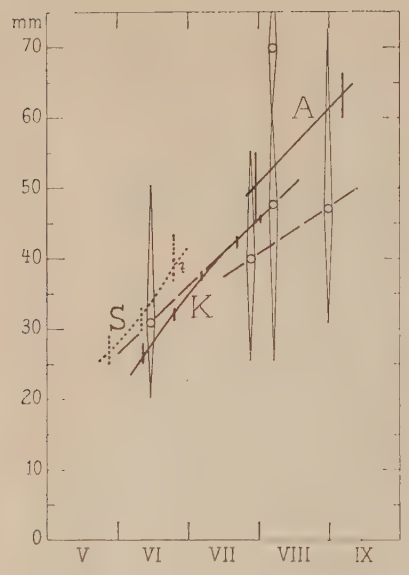

Figure 3. Growth of herring larvae in the western Baltic, from German investigations (H. A. Meyer 1874—76). The vertical lines illustrate the length distribution of the larvae, the oblique lines their growth. S: larvae measured in Slien, K: transferred from Slien to the Kiel Bay and put out in a container woven of horse-hair and suspended in free water, A: in tank with running sea-water. The spindle-shaped figures show the length distribution and mean lengths of larvae at the mouth of the Trave, measured by K. Altnöter in 1926; the broken lines show the supposed growth.

Bay were kept in a tank with constantly renewed sea-water[1]). The figure further contains measurings carried out in 1926 by K. Altnöter in the broads at Travemunde[2]). It is doubtful how Altnöter's measurements should be connected, and the growth was possibly less rapid than illustrated by the plotted growth lines. Meyer calls attention to the fact that the growth gets comparatively slow when the herring larva changes to the shape of the adult herring because at this time it grows very much in breadth and height. However, the growth found in measuring the herring larvae from the ring-trawl must become too small because many of the herring migrate to the vicinity of the coast when they have taken the shape of the adult herring, and they can often be seen standing in shoals at places sheltered from the current, for instance at piers. The spring herring, which begin to get their scales already at a length of 3 cm. and have the shape of the adult fish when they are little more than 4 cm. long, no doubt disappear from the open waters at a smaller size than the autumn herring, which do not begin to get their scales until they are more than 4 cm long. In partially closed areas like the mouth of Slien and the broads of Travemünde the small and big herring larvae and young fish of 4—8 cm. are no doubt found together to a much greater extent than in the open Danish waters, from which the comparisons of figure 2 originate.

Figure 5 shows the mean lengths for each length group caught in 1927—39 within the areas c and e, i. e. the Great Belt and the Belt Sea N. of Funen together with the area E. of Djursland. To some extent, it is seen, they gather into groups, the mean lengths of which rise towards the right and group round growth lines plotted with the ascents found in figure 2. This is especially true of the large group in which the mean length on 1st April is about 10 mm., on 10th May about 20 mm.

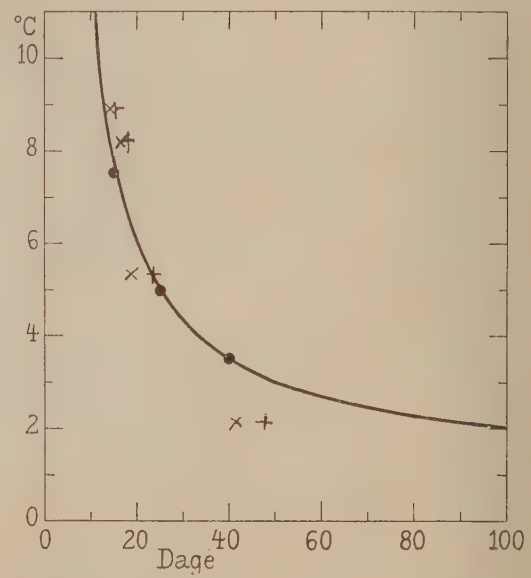

Figure 4. The hatching of the herring egg at different temperatures from H. A. Meyer's experiments with eggs of autumn herring from Korsør. The curve shows the connexion between the temperature (t) and the hatching time in days (d) according to A. C. Johansen's formula: d (t—1) = 100, which is based on Meyer's experiments. The points marked × show the day of the first hatching and + the day when half the eggs of the Norwegian spring herring are hatched (from Peder A. Soleim, 1942).

[1]) H. A. Meyer: Beobachtungen über das Wachstum des Herings im westlichen Theil der Ostsee. Jahresbericht der Commission zur wissenschaftlichen Untersuchung der deutschen Meere in Kiel. IV., V. und VI. Jahrg. 1878.

[2]) K. Altnöter: Untersuchungen an den Heringen der westlichen Ostsee. Bericht der Deutschen wissensch. Kommission für Meeresforschung. N. F. IV, 3, 1928.

Table 5. Mean temperatures from observations of the Meteorologisk Institut.

		Dec.	Jan.	Feb.	March	April	May
Anholt Knob	0 m.	4.1	2.2	1.4	1.9	4.5	9.4
	10 -	4.8	2.8	1.9	2.2	4.3	8.5
	20 -	7.3	4.9	3.8	3.7	4.1	5.3
	28 -	8.1	6.1	4.7	4.3	4.3	4.9
Schultz's Gr.	0 -	4.2	2.1	1.5	2.0	4.6	9.3
	10 -	..	2.6	1.8	2.2	4.3	8.3
Kels Nor (Southern Langeland)	0 -	4.1	2.0	1.2	2.0	4.7	9.2
Oddesund (Western Limfjord)	0 -	2.5	1.1	1.0	2.1	6.0	10.9

It is of course possible to find the approximate date of the hatching of the larvae, the mean length of which in April is 12—15 mm., if we extend the growth lines backwards until they reach the length at the hatching, about 6 mm. Most probably the growth in March and the beginning of April is a little slower than at the end of April and in May, partly because the temperature is lower (see table 5), partly because the amount of nourishment at this early time has not yet reached its maximum. Therefore the rise is no doubt a little too steep in the dashed lines plotted in figure 2 for the purpose of illustrating the first growth of these herring larvae.

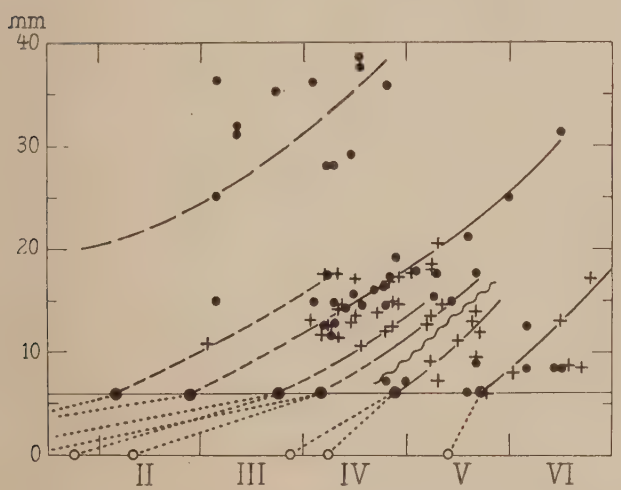

Figure 5. Mean lengths of herring larvae caught in area c: E. of Djursland and round Samsø (+) and in area e: the Great Belt and Smaalandsfarvandet (between Sjælland and Laaland (●) in February—June with growth lines extended to the length at the hatching, about 6 mm. The hatching date is marked with ● and is connected with the approximate spawning date marked ○ by dotted lines. In some cases two dotted lines have been drawn to approximate dates between which the spawning must have taken place. However, they only illustrate the hatching time for eggs found in the upper water layer. Most of the larvae of 10—22 mm, that are found in April are winter herring from the lower water layer of the Kattegat and are hatched within 20—30 days. The comparative scantiness of larvae in May—June is caused by the fact that only few researches were made in these months. The undulating line denotes the limit between winter and spring herring.

The time elapsing between the spawning and the hatching of the eggs depends very much on the temperature: at 1° C. and below practically no development takes place, at 2° C. it lasts about 3 months, at 3° about 50 days, at 4° about 1 month, at 6° 20 days and at temperatures above 10° C. 10 days. This dependence is illustrated in figure 4, which is based partly on researches upon the roe of autumn herring from the Belts[1]), partly on Peder A. Soleim's[2]) investigations on the Norwegian spring herring.

It is seen that the development of the eggs of the two herring races is very different, and so it cannot be told beforehand how the spring spawners of the Danish waters will react. It may be expected that the eggs of these herring which, like the Norwegian spring herring, are normally hatched at a lower temperature than the autumn spawners of our inner waters, will show much the same characteristics as the Norwegian spring herring.

Figure 6 shows the numbers of 10—22 mm. herring larvae caught per 30 minutes in April of different years. It is seen that the largest quantities of these larvae were found at Anholt and southwards to the Sound and the northern Belt Sea, E. of Samsø, but also further southwards through the Great Belt to a position E. of Langeland. They are larvae of the winter herring of the Kattegat, the principal spawning places of which are found in the central Kattegat at depths of more than 20 m.[3]). The largest amounts of larvae are often found near the bottom, and though

[1]) H. A. Meyer: l. cit. 1878.

[2]) Peder A. Soleim: Årsaker til rige og fattige Årganger av Sild. Fiskeridir. Skr. VII, 2. 1942.

[3]) A. C. Johansen: Über die Winterheringe des Kattegats. Wiss. Meeresunters. N. F. XV. Abt. Helgoland. 1923.

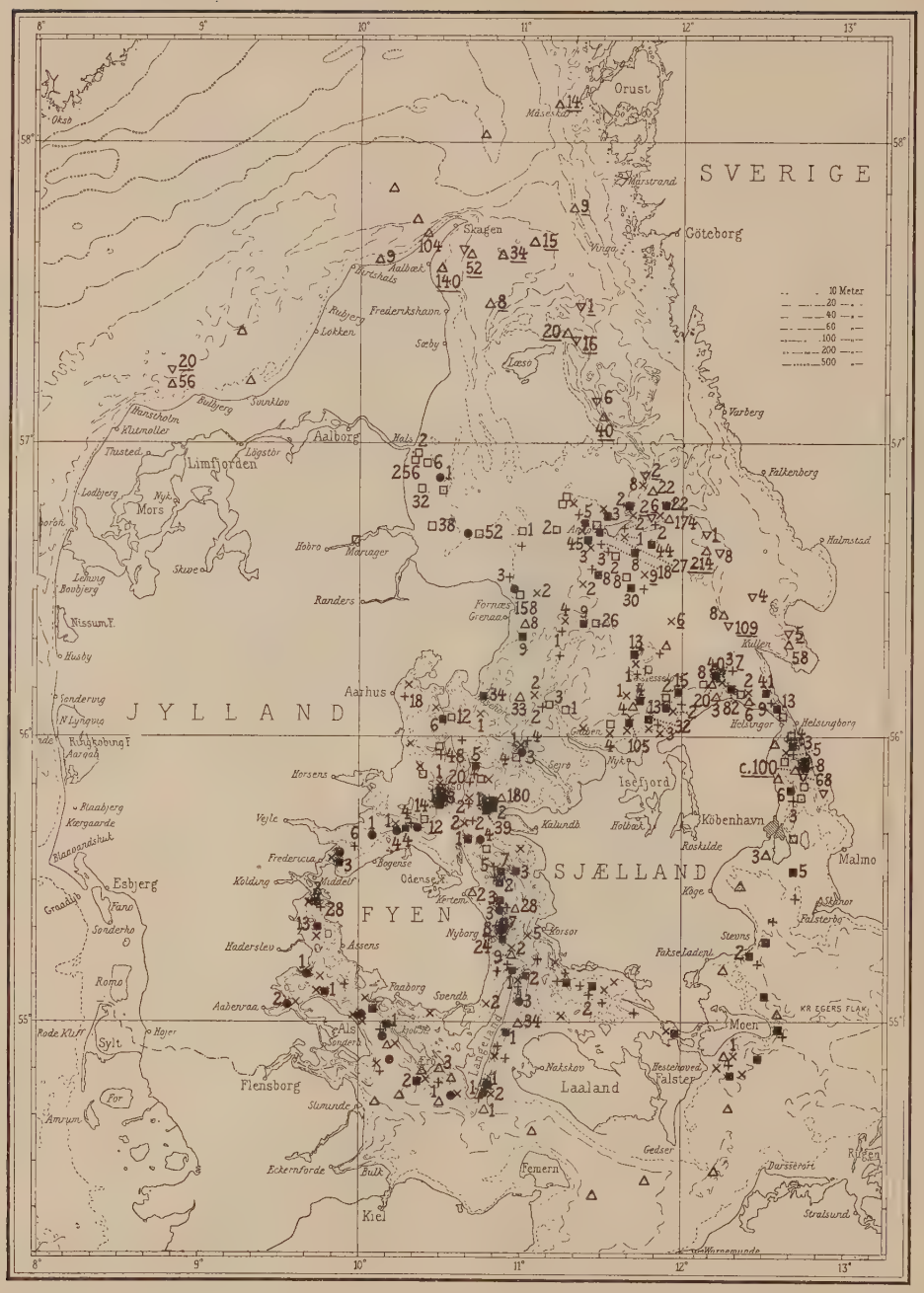

Figure 6. Numbers of 10—22. mm herring larvae (mostly winter herring) caught per 30 minutes in April of different years Underlined figures: caught in the young-fish-trawl, the rest in the ring-trawl. (For explanation of symbols see figure 9).

they often abound in the upper water layer, especially by night[1]), many of them must therefore be carried along by the lower water layer, which in February-April takes a little less than one month to carry the water from Anholt Knob to Schultz's Grund[2]).

This herring is closely related to the Norwegian winter (spring) herring and may be identical with one of its forms spawning at the Skagerrak coast of Norway. The larvae of the Norwegian "spring" herring are carried westwards by the Baltic current, and during the fishing experiments with the young-fish-trawl and the ring-trawl, all of which were carried out S. of the Norwegian Channel, very few larvae of winter herring were found.

The opinion has been advanced that the same or a closely related race of winter herring has extensive spawning places in the deep channels of the northern Belt Sea[3]). This supposition is exclusively based on the fact that a comparatively large amount of larval winter herring may occur in this area (cp. figure 6); the Kattegat winter herring has never been found in the Belt Sea during the racial investigations, and as far as we know spawning herring have never been observed in or near the deep channels when trawling here during Febr.-March e. g. for small whiting. As mentioned above it is by no means remarkable that larvae of the winter herring of the Kattegat are carried to this locality and much further into the Belt Sea. It remains a problem, however, whether the winter herring of the Kattegat sometimes spawns within this area. In some years the salinity and the temperature may be as high here as in the spawning places between Anholt and Læsø, 32—33 $^{0}/_{00}$ and 4—6° C., but they are generally lower, and it is only an irregular occurrence of inflows or submarine waves that sometimes for about a fortnight on end makes the temperature and salinity rise so much within this area. It should also be remembered that the deep channels contain only few localities in which the bottom is so firm that the herring can find suitable spawning places: the bottom of this area nearly everywhere consists of soft mud. However, we cannot exclude the possibility that a less extensive spawning of winter herring sometimes takes place here when a wave of salt water has carried them into the area (cp. also p. 32).

Corresponding to the comparatively high temperature at which the winter herring of the Kattegat spawns the time between spawning and hatching is only 20—33 days. In figure 5 straight lines have been drawn between the points representing the hatching date and circles at the length 0, representing the time of spawning of eggs that have been spawned in the upper water layer. As the said large group of herring larvae found in April mainly consists of winter herring of the Kattegat, the eggs of which are hatched in the warm bottom layer, this group of larvae must originate from spawnings about the middle of February, i. e. from the middle of the spawning time of this race.

There are also herring which spawn in winter in the southern Lesser Belt (Lille Belt). According to information from the fishermens sales-union at Assens spawning took place on 20th Dec., 1948, at Illumø in the Helnæsbugt (south-west Funen). Up to then the herring had always been full, but on this day the roe had been deposited in the pound nets standing at a depth of 2.5 m. in such quantities that the meshes were completely filled. A racial examination showed that these winter herring were very much like the spring herring of the Belt Sea but in some characters resembled the autumn herring of the Belt Sea. In figure 12 where the points of time have been plotted at which spawning herring were found in the different waters we see that no sharp limit exists between the spawning times of the winter herring and the spring herring in the Western Baltic and the Lesser Belt.

The spring herring of the Danish waters also spawn in quite shallow water, especially near the coasts, in Smålandshavet between Sjælland and Laaland no doubt also on the shallows Kirkegrund and Vanegrund. As far as we know Davids Banke N. of Bornholm is the only locality where a spawning in spring (May) takes place in somewhat deeper water (minimum depth of the bank 12 m.). In May 1875 spawning of the spring herring was observed by V. Hensen in the broads at the mouth of Slien. Here the eggs were found to have been attached to the weed *Potamogeton natans*, to dead shells, stones

[1]) A. C. Johansen: On the diurnal vertical Movements of Young of some fishes in Danish Waters. Medd. f. Komm. f. Havunders. Ser. Fiskeri VIII, 2. 1925.

[2]) Aage J. C. Jensen: Fluctuations in the Hydrography of the Transition Area during 50 Years. Rapp. et Procès-Verb. 102, I. 1937.

[3]) A. C. Johansen: On a Spawning Place for winter spawning Herring in the northern part of the Belt Sea. Rep. Dan. Biol. Stat. XXXIII. 1927. E. M. Poulsen: The Herring Stocks of the Transition Area. Rapp. et Procès-Verb. C, 2. 1936.

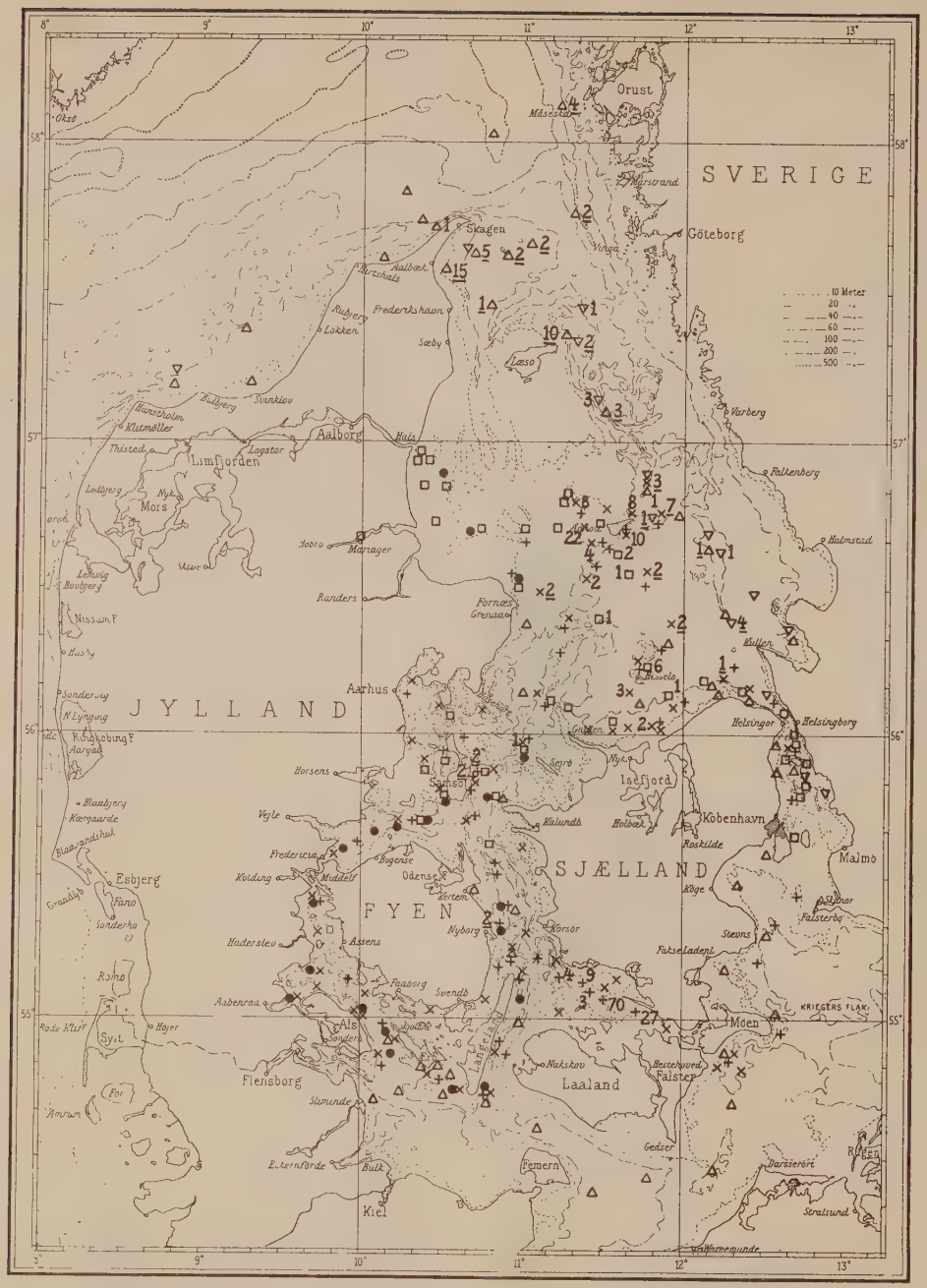

Figure 7. Numbers of herring larvae of less than 10 mm. length caught per 30 minutes in April. Underlined figures: caught in the young-fish-trawl; the rest caught in the ring-trawl (for explanation of symbols see fig. 9).

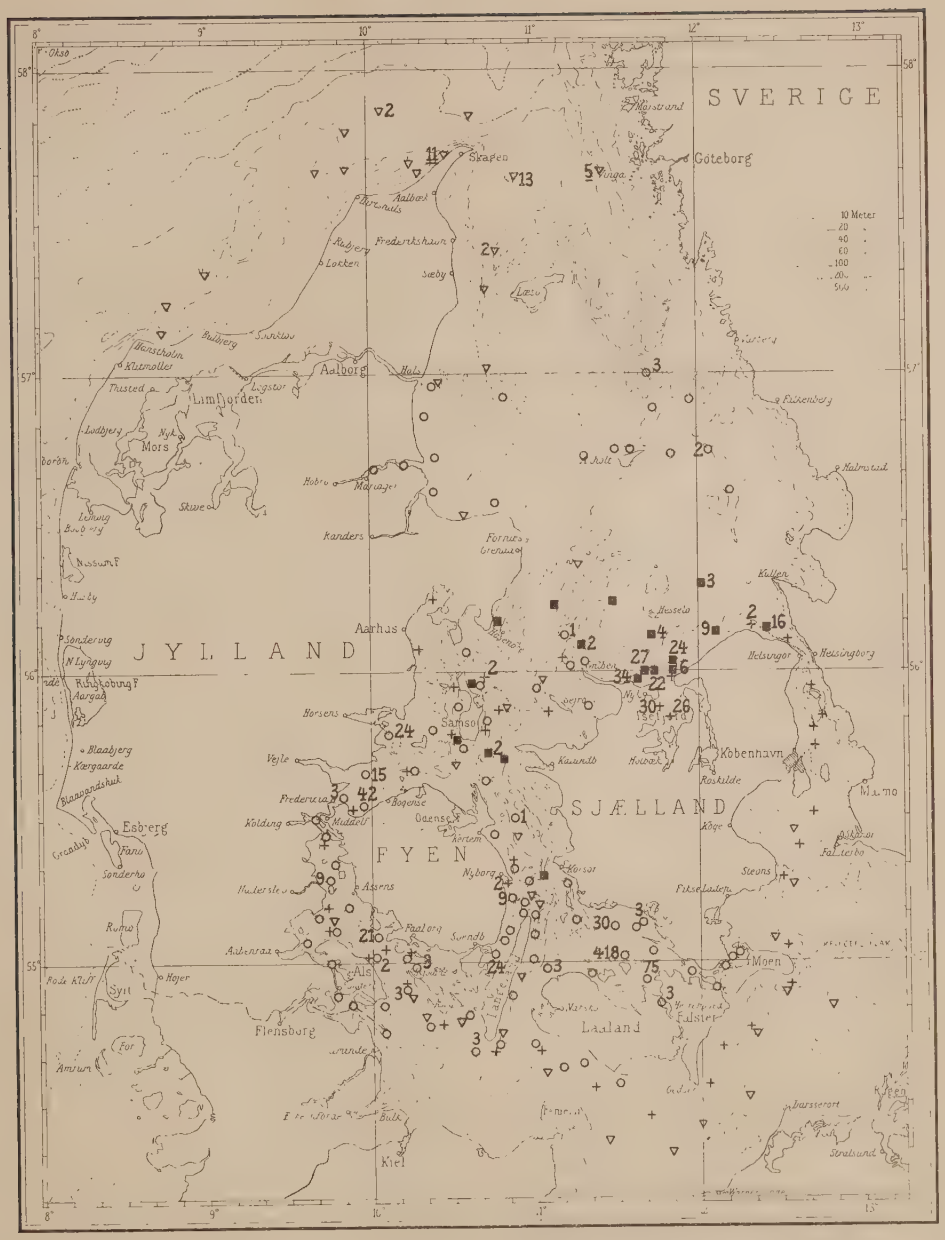

Figure 8. Numbers of herring larvae of less than 10 mm. length caught per 30 minutes in May. Underlined figures: caught in the young-fish-trawl; the rest caught in the ring-trawl (for explanation of symbols see fig. 9).

and the sandy bottom at 1—2 m. depth. The milts of the herring coloured the water[1]), a fact which has also been observed in many localities near the Danish coasts.

The spring herring spawn from the end of March to the beginning of June except in the said locality on Davids Banke in May and at the north coast of Møen where the spawning in most years no doubt principally takes place in March. The positions of the spawning places are shown in figure 1. The importance of the different spawning places appears from the maps figs. 7 and 8, which give the catches per 30 minutes of larval herring of less than 10 mm at the end of April and in May, respectively, of the different years. Figure 5, in which lines have been drawn between the dates of spawning and hatching, shows us that these herring originate from the end of March and later spawnings. The limit between the larvae of winter and spring spawners may be put at the waved line plotted in figure 5. However, there must be some variation from year to year in this limit on account of the variation in the conditions of temperature.

The principal spawning places of the spring spawners are Smålandshavet, the Isefjord and the north coast of Sjælland. At this time there may also be an extensive spawning in the western Baltic, in the Vemmingbund, at the mouth of Slien and in other localities. If we compare the amounts of larvae of the herring spawning in spring (fig. 8) to those of the herring spawning in autumn (fig. 9), we find that the larvae of the spring spawning herring are very scantily represented. This fact can be explained in several ways: investigations in the end of May and in June, when the highest numbers of larval spring herring are found in the water, were carried out in few years only; the spawning of the spring herring extends over a longer period than that of the autumn herring; the growth of the larval spring herring is more rapid than that of the autumn herring because the water in spring contains more nourishment.

Racial investigations (especially by Fr. Heincke, A. C. Johansen, K. Altnöter, K. A. Andersson, Ch. Gilis, Chr. Hessle, E. Lea, S. Runnström, W. Cieglewicz, H. Wood and the present author) have gradually given us a fairly extensive knowledge of the different tribes or races spawning in the individual localities of the seas round Denmark and of their migrations though it must be admitted that many important questions have not yet been answered.

The races of winter and spring herring that are of importance in the Danish fishery have the following spawning places (cp. the map fig. 1).

Winter (or spring) herring. At the north coast of Scotland: the Scottish spring herring; at the west coast of Norway: the proper Norwegian "spring" herring; according to S. Runnström in the northernmost region of the North Sea (at the Viking Bank and in other localities): the Norwegian "Storsild" (it is not certain whether these Norwegian herring races are represented in the Danish catches); at the Skagerrak coast of Norway: the Norwegian "spring" herring of the Skagerrak, some of which are possibly identical with the Kattegat winter herring spawning in the northern and central Kattegat. According to A. C. Johansen a deep-water winter herring possibly also spawns in the northern Belt Sea[1]), but it must be noted that in 1927 and in other years with a numerous occurrence of larval winter herring in this area there was an exceptionally strong inflow to the area from the Kattegat and that it seems impossible to distinguish between the larvae area in the northern and central Kattegat and a larvae area in the northern Belt Sea. The larvae of the latter area and, sometimes, of the Sound seem to originate from the Kattegat area, so that their number seems to be determined by an inflow with the currents (see fig. 6). Likewise, the extensive trawl fishery carried on during the winter months of some recent years seems to have proved no presence of winter herring going to spawn within this area. In the southern Lesser Belt we find the coastal winter herring of the Belt Sea, which presumably has more spawning places than that marked down on the map at Helnæs.

Spring herring. At the coast of the Skagerrak: the Jammerbugt herring; in the Aalbækbugt: the spring herring of the northern Kattegat, perhaps of the same race as that of the Swedish coast of the Kattegat; in the Limfjord and the central and southern Kattegat: the Ålborg herring (which can perhaps be divided into a Limfjord and a Kattegat

[1]) C. Kupffer: Über Laichen und Entwicklung des Herings in der westlichen Ostsee. Jahresbericht zur wissenschaftlichen Untersuchung der deutschen Meere in Kiel. IV., V. und VI. Jahrg. 1878.

[1]) A. C. Johansen: On a Spawning Place for winter spawning Herring in the northern part of the Belt Sea. Rep. Dan. Biol. Stat. XXXIII, 1927.

race). A. C. Johansen put up a separate race: the Thyland herring with spawning places at the western side of the isthmus at Thyborøn and possibly sometimes in the broads of Nissum and Thisted[1]); but the deviations in racial characters from the spring herring of the Limfjord mentioned above seem to be due to admixtures from other races (Jammerbugt herring or autumn herring of the North Sea).

In the Belt Sea and to some extent in the western Baltic: the spring herring of the Belt Sea; in the rest of the western Baltic: the spring herring of the western Baltic. Another race spawns at Møen; it is possibly identical with the race at Rügen. Several different races of coastal spring herring spawn in the eastern Baltic E. of Rügen-Schonen, a separate race perhaps in deeper water (at Davids Banke).

Local races are also found in some fjords, but their numbers are highly varying, and for long periods they may seem to be totally lacking.

Fluctuations from year to year in distribution, quantity and length of the larvae of the winter herring.

We have but few and insufficient investigations on the larvae of the winter herring while they are less than 10 mm. long; our examinations must therefore be confined to the changes in the bigger larvae, the distribution and amount of which must differ very much from year to year because the currents vary.

From fishings with the young-fish-trawl, which, as mentioned above, was often used quite close to the bottom, we know that there are mostly more larvae at the bottom than higher in the water. From hauls with the ring-trawl by day and night at a station in the southern Kattegat in April 1923 A. C. Johansen[2]) found that in the afternoon and the night there were nearly twice as many larval winter herring of 10—18 mm. length at 4 m. than intermediate at 16 m. depth. By night the quantity of larvae in the upper water layer was very considerable. The current of the lower water layer, which always goes in the direction of the Baltic, is very slow in comparison to the current of the upper layer, which mostly has an outward direction, but is not rarely inward bent for some days on end, sometimes even in the monthly mean. Though the larvae on the whole are thus mostly carried inward by the current of the lower water layer, there may also be considerable transport in the upper layer. During the spring months the transport of water from Anholt to the Schultz's Grund in the lower layer lasts a little less than one month, but the larvae are sometimes carried from the central Kattegat to the Belt Sea in the course of a couple of days in the upper layer. In most cases, however, they must be carried northwards by the surface current, especially along the eastern side of the northern Kattegat and the Skagerrak, but investigations are too few for an establishment of their occurrence in this area.

If the larvae were only found in the lower water layer, it must be expected that the larval winter herring of 10—22 mm. length in April would mostly occur in the Sound and the northern Belt Sea and in May even more southerly. In April, however, these larvae show a fairly uniform distribution in the central Kattegat, the area N. of Sjælland and the northern Belt Sea; this fact alone shows that the surface current plays a considerable part in their transport.

From table 2 we learn that in the Anholt area the larvae below 10 mm. were much more numerous in 1935 than in 1930, 34, 36, 37 and 38. In 1935 the temperature at bottom at the Anholt Knob light-vessel was exceptionally high in January and the beginning of February, the mean of January being 8.5° C. while the mean of a longer series of years was 6.1—in January 1935 it was 1—2° higher than in each of the other years mentioned. The spawning of the winter herring had no doubt been delayed in 1935.

The temperature of the lower water layer in January—March might be expected to have a considerable effect upon the amount, length and distribution of the larvae in April because a low temperature will lengthen the hatching time of the eggs, but this seems not to be the case.

In 1937 particularly many larvae of 10—22 mm. length were found in the Anholt area, N. of Sjælland and to some extent E. of Djursland and in the Samsø Belt. In this year the salinity of the lower water layer was uncommonly high, 33.8—33.7 ‰ at the Schultz's light-vessel at bottom in March and April, respectively. A. C. Johansen has pointed out

[1]) A. C. Johansen: The Ålborg Herring and its Importance to the Danish Herring Fishery from the XVIth Century until the Present Day. Rep. Dan. Biol. Stat. XXXV, 1929.

[2]) A. C. Johansen: l. cit. 1925.

that the rapid inflow in the spring of 1923 brought many larvae of winter herring into the Belt Sea[1]), and in this year many larvae of winter herring were also found in the central Kattegat. In the years 1927—39 the second highest salinities of March-April in the lower layer occurred in 1930 and 1927; it appears from table 2 that also these two years showed large amounts of larvae in the areas c and d.

Undoubtedly, however, there is also a demonstrable connexion between the variations in the salinity of the upper water layer and the distribution of the larvae. By strong easterly winds in 1934 there was an uncommonly rapid outflow in April which reduced the mean salinity for this month to 15.3 at Anholt Knob, i. e. 4 ‰ below the normal. In this year particularly many larvae of winter herring were found in the western Kattegat (see table 2 and fig. 6). Also in 1932 there were strong easterly winds with a comparatively low surface salinity and large amounts of larval winter herring in the western Kattegat.

The connexion between the surface salinity and the frequency of larvae in the southern areas also appears from a calculation of the correlation coefficient.

The correlation coefficient is a kind of mean figure for the correspondence between two sets of observation. A comparison is made between the deviations from the mean value for each of the two series of observation. A positive coefficient means that there is mostly a deviation to the same side, positive or negative, in the sets or pairs of the two series; a negative coefficient means that there is mostly a deviation to the opposite sides in the corresponding pairs of deviation.

If the coefficient is 1.0 or —1.0, the deviations are in strict proportion. If the coefficient is 0.0, there is generally no correspondence between the two series. The more the coefficient approaches 1.0 or —1.0 the greater the correspondence.

The coefficient (r) is calculated from the formula

$$r = \frac{\Sigma ab - \frac{\Sigma a \cdot \Sigma b}{n}}{\sqrt{\left(\Sigma a^2 - \frac{(\Sigma a)^2}{n}\right)\left(\Sigma b^2 - \frac{(\Sigma b)^2}{n}\right)}},$$

where a and b are corresponding pairs of deviations in the two series, calculated either from the real mean figure or from a more or less approximate mean figure, and n is the number of pairs.

The significance of the found correspondence or correlation coefficient is measured by the standard error of the coefficient σ_r; it may be considered significant if r is 3 times as great as σ_r, $\left(\sigma_r \text{ is calculated from the } \sigma_r = \frac{1 - r^2}{\sqrt{n}}\right)$. Or it is possible to calculate the probability that a lower correlation coefficient would be found if the examination is repeated to the same extent with other series of observation of the same phenomena, for instance the simultaneous quantities of herring larvae in two definite areas (all other things being equal). If the probability (P) is 0.1, on an average 1 of every 10 series of observation will give a (numerically) lower coefficient than the found coefficient; if P is 0.02 only 1 of every 50 series of observation will give a lower coefficient. In order to find P we first calculate t (test of significance) from the formula $t = r \frac{\sqrt{n-2}}{\sqrt{1-r^2}}$. P can then be read directly from Fisher's table IV[1]).

The calculation of the standard error has been the common procedure, but in contrast to the calculation of P this calculation requires a very comprehensive material and may lead to false conclusions if the material (the number of pairs of ob-observation) is comparatively small (l. cit. p. 161), which is nearly always necessarily the case in investigations on fishery biology. Therefore the estimate of the significance by means of P has been used here. A coefficient is generally considered "significant" if P is lower than 0.05.

The correlation coefficient between the amount of 10—22 mm long larvae in area c in April and the surface salinity at Schultz's Grund in March is 0.46 for the period 1929—39. It is too low to be considered significant, but it shows that in these years there has been a certain although inconsiderable correspondence, and it may be concluded that other conditions must exercise a great influence on the amount of larvae.

The larvae of the winter herring were exceptionally big in 1934 (see tables I—VII), which may be due to a particularly early hatching or a particularly

[1]) A. C. Johansen: Om den stærke Indstrømning af Saltvand til vore indre Farvande i Foraaret 1923 og dens Indvirkning paa Dyrelivet. Naturens Verden, 1926.

[1]) R. A. Fisher: Statistical Methods for Research Workers. 1930.

rapid growth. The bottom temperature in the northern Kattegat was not unusual in this year. The bottom salinity was nearly normal in the spring months, but about December 1933 there had been an exceptionally vigorous inflow of salt water, which raised the salinity at Anholt Knob to 34 ‰ while the normal is 32.2. Perhaps the large amount of larvae and the great length of the larvae in this year are consequences of the greater inflow of nutritary salts.

The larvae of the autumn herring.

The investigations in autumn were carried out in October-November, a few of them in September and December 1927—38; to a great extent they were carried out in collaboration with Sweden and Germany, each of the countries mostly fishing in the areas situated at the smallest distance from the country in question.

In contrast to the herring larvae taken during the researches in spring the larvae caught in the autumn comprise only one size-group.

The distribution of the larvae in the waters in autumn.

As in the case of the winter and spring herring our knowledge of the situation of the spawning places is rather incomplete, but in the main the map of fig. 10 is correct.

The races of autumn herring (on winter and spring

Table 6. Mean number of herring larvae per 30 minutes from autumnal investigations in October—November (numbers of stations in brackets).

Area	b		c		d		e		f		g		Bornholm	
Year	below 9 mm.	above 9 mm.	below 9 mm.	above 9 mm.	below 9 mm.	above 9 mm.	below 9 mm.	above 9 mm.	below 9 mm.	above 9 mm.	below 9 mm.	above 9 mm.	below 9 mm.	above 9 mm.
1927	3 (4)	0	9 (1)	00	.. ..	..	52 (22)	4	29 (48)	0	50 (32)	9	37 (17)	0
1928	0 (5)	0	339 (11)	14	4 (9)	4	754 (19)	66	101 (48)	17	250 (34)	21	3 (22)	21
1929	338 (4)	25	13 (12)	2	5 (8)	16	80 (19)	12	71 (42)	6	340 (37)	53	45 (47)	31
1930	130 (12)	70	26 (14)	2	6 (7)	10	36 (18)	5	36 (53)	2	46 (43)	5	2 (35)	4
1931	30 (6)	9	140 (10)	21	4 (5)	10	108 (18)	18	22 (18)	3	72 (34)	12	16 (36)	19
1932	8 (11)	23	125 (10)	3	1 (5)	6	33 (19)	4	17 (18)	1	80 (25)	13	2 (19)	3
1933	7 (11)	5	14 (14)	2	10 (4)	18	14 (15)	5	2 (17)	1	35 (8)	5	.. (0)	..
1934	8 (14)	14	39 (12)	5	23 (5)	17	23 (17)	3	6 (9)	0	61 (22)	2	.. (0)	..
1935	4 (11)	7	21 (11)	3	0 (7)	0	67 (13)	4	1 (6)	0	36 (16)	2	.. (0)	..
1936	6 (19)	2	19 (17)	3	2 (5)	0	93 (17)	5	2 (6)	1	30 (14)	6	.. (0)	..
1937	.. (0)	..	3 (17)	2	2 (7)	3	4 (13)	7	5 (7)	1	15 (16)		.. (0)	..
1938	.. (0)	..	38 (29)	1	1 (8)	0	8 (16)	1	5 (6)	1	5 (11)	1	.. (0)	..
Mean	53 ..	..	66 ..	5	5 ..	8	106 ..	11	25 ..	3	85 ..	11	18 ..	10

Table 7. Mean lengths of herring larvae caught in the ring-trawl in October. (Numbers of individuals in brackets). Cm.

Year \ Area:	c	d	e	f	g
1927	6.98 (84)	.. ..	7.61 (1146)	7.28 (443)	8.25 (1885)
1928	8.00 (1151)	10.13 (55)	8.02 (5581)	7.84 (741)	7.76 (4287)
1929	7.25 (85)	11.27 (89)	8.40 (985)	8.19 (37)	8.03 (2981)
1930	6.66 (327)	10.15 (68)	7.55 (471)	7.69 (1117)	7.77 (1264)
1931	7.96 (933)	10.91 (44)	8.17 (1830)	8.14 (205)	8.39 (1635)
1932	7.17 (472)	10.68 (25)	8.00 (612)	7.59 (309)	8.19 (1561)
1933	7.24 (225)	10.20 (75)	8.49 (202)	8.89 (35)	7.87 (265)
1934	7.87 (494)	8.62 (125)	7.68 (368)	7.33 (54)	7.77 (1030)
1935	8.54 (309)	10.50 (2)	7.67 (1030)	7.67 (3)	8.01 (408)
1936	7.92 (307)	8.06 (17)	7.64 (1862)	7.67 (18)	7.89 (586)
1937	9.34 (91)	10.19 (26)	10.15 (132)	8.63 (30)	9.03 (270)
1938	6.84 (1187)	9.50 (6)	7.45 (150)	6.97 (40)	7.28 (43)

Furthermore the mean length in 1930 in area a was 13.58 (36), in area b 9.42 (908); in 1936 it was 8.11 (53) in area b.

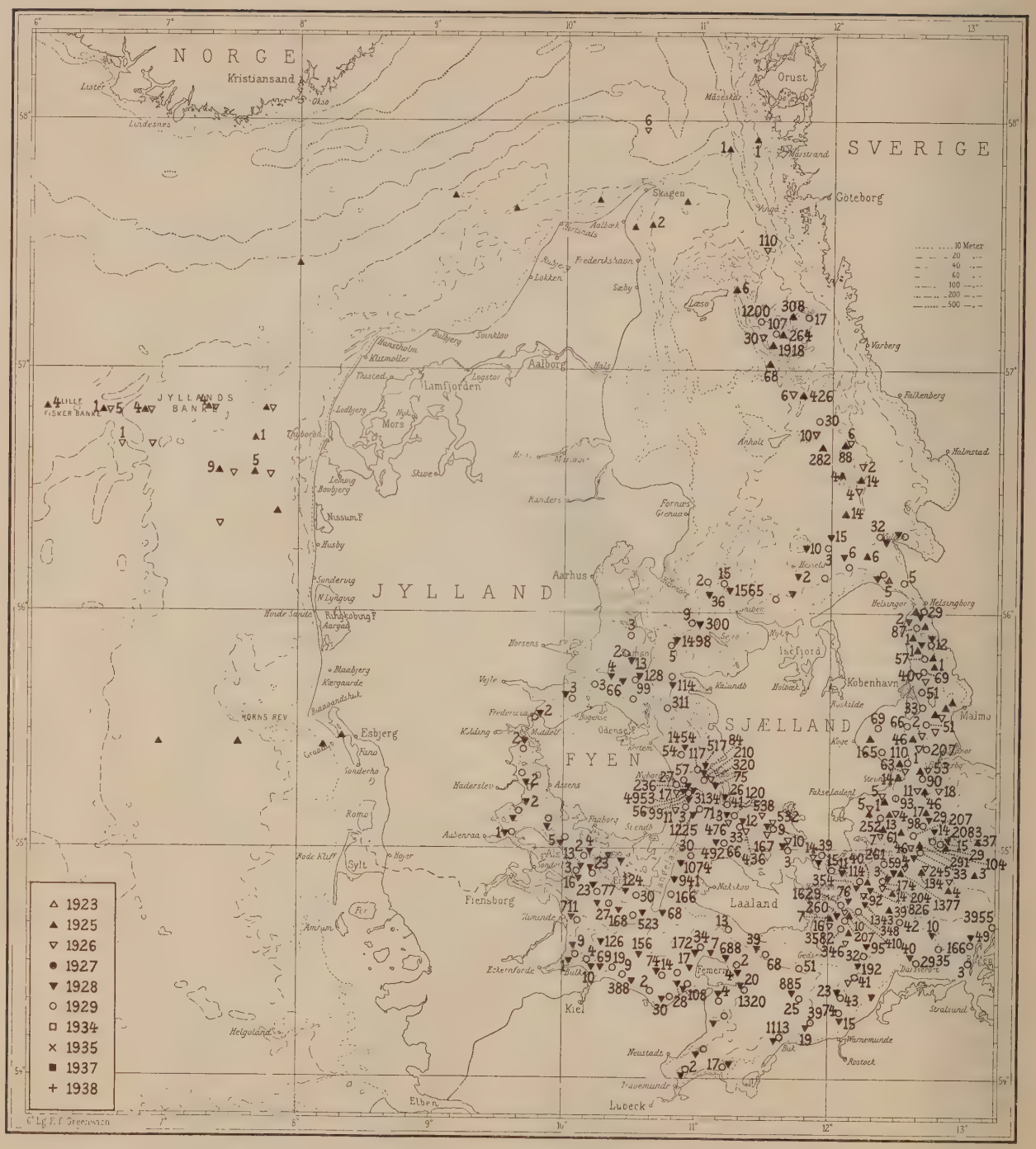

Figure 9. Numbers of herring of less than 10 mm. caught in the ringtrawl per 30 minutes in October.

Figure 10. Schematic illustration of the spawning places of autumn herring. The dots represent the spawning places of the Kobbergrund herring, the black fields the spawning places of the coastal autumn herring. Other spawning places of autumn herring playing a part in the Danish fishery are found in the western half of the North Sea, at the coasts of Bornholm, at the Baltic coast of Sweden at Hanö (W. of Sandhammeren) and northwards and at the south and east coasts of the eastern Baltic. On the herring races see p. 38.

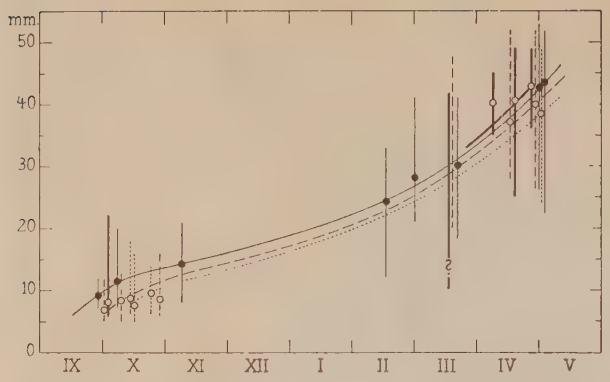

Figure 11. Lengths of the larval autumn herring in catches from the ring-trawl in September-May. Vertical lines illustrate the length distribution. (——— Jutland Reef, – – – – the southern Kattegat and the Samsø Belt, ····· the Great Belt, ——— the Sound-Møen area); • mean lengths in the Jutland Reef area, ○ in the inner Danish waters.

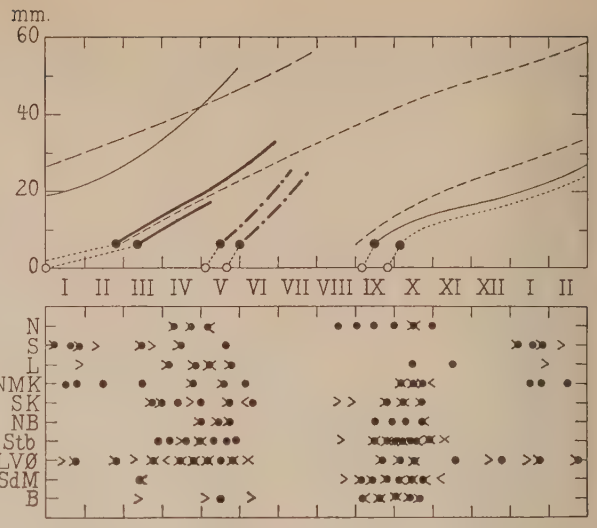

Figure 12. Lower half: the spawning times of the herring in the individual waters. • indicates that spawning herring have been observed, > that a considerabie part of the catches approach the spawning stage, < that a considerabie part of them are spents.

N: the eastern North Sea, S: the Skagerrak, L: the Limfjord, NMK: the northern and central Kattegat, SK: the southern Kattegat, NB: the northern Belt Sea, StB: the Great Belt, LVØ: the Lesser Belt—the western Baltic, SdM: the Sound—Møen area, B: Bornholm.

Upper half: the growth of the herring larvae.

——— winter herring in the inner Danish waters.

—·—· spring herring in the inner Danish waters.

——— autumn herring in the Jutland Reef area.

····· autumn herring in the southern Kattegat and the Great Belt area.

– – – – spring and autumn spawning herring at St. Andrews, east coast of Scotland, from A. T. Masterman, 14. Rep. Fish. Board of Scotland.

As in fig. 5 dotted lines join the symbols indicating the length at the hatching (•) and the approximate spawning time (○).

As regards the winter herring of the Kattegat, however, the hatching time is shorter than indicated in the figure, being only 20—30 days.

herring see p. 32) that are important in the Danish fishery have the following spawning places:

In the western half of the North Sea: several races of the summer and autumn herring of the North Sea; in the Jutland Reef area (according to A. C. Johansen) at any rate in some years: the autumn herring of the North Sea; at the North Sea coast of the Thyborøn isthmus and Thy: the autumn herring of West Jutland, according to A. C. Johansen also in Jammerbugten and perhaps sometimes in Nissum Bredning; in the northern Kattegat at 20—40 m. depth: the Kobbergrund herring; at the coasts of Læsø, Anholt and sometimes at Djursland: the big autumn herring of the Kattegat; in the southern Kattegat and the northern part of the Belt Sea, the Great Belt and at any rate sometimes in parts of the western Baltic: the autumn herring of the Belt Sea; in the western Baltic: the autumn herring of the western Baltic; in the Stevns-Møen area, presumably also on the western side of Rügen: the Sound herring; at Bornholm: the Bornholm herring; at the south coast of Schonen (Hanöbugten, W. of Sandhammeren), the east coast of Sweden and the coasts E. of Rügen: several races of autumn herring.

Table 8. Correlations between the variations from year to year in the number of herring larvae in different areas.

	c E. of Djursland-Samsø Belt	d N. of Sjælland	e Great Belt	f Western Baltic–Lesser Belt
d. N. of Sjælland	—0.13	..	..	..
e. Great Belt	0.84	—0.14	..	..
f. Western Baltic-Lesser Belt	0.70	0.03	0.82	..
g. The Sound, Møen area	0.41	0.18	0.53	0.85

Table 9. Correlations between the variations from year to year in the mean length of the herring larvae in different areas.

	c	d	e	f
d. N. of Sjælland	0.05	..	..	..
e. Great Belt	0.64	0.25	..	..
f. Western Baltic-Lesser Belt	0.34	0.36	0.75	..
g. The Sound, Møen area	0.63	0.32	0.76	0.52

Table 10. Correlation between the amount of herring larvae in October and the salinity.

	Surface salinity			Bottom salinity		
	Schultz's Gr.	Halskov Rev	Drogden	Schultz's Gr.	Halskov Rev	Drogden
	Amount of larvae in			Amount of larvae in		
Salinity in	c	e	g	c	e	g
June	0.34	0.78	0.21	0.15	—0.04	0.17
July	0.56	0.40	—0.01	—0.50	0.16	—0.13
August	0.17	0.04	0.04	—0.57	—0.51	—0.17
September	—0.11	—0.36	0.03	—0.25	—0.31	0.03
October	—0.28	—0.43	—0.20	0.38	0.00	—0.40

Table 11. Correlation between the amount of herring larvae in October and the temperature.

	Surface temperature			Bottom temperature		
	Schultz's Gr.	Halskov Rev	Drogden	Schultz's Gr.	Halskov Rev	Drogden
	Amount of larvae in			Amount of larvae in		
Temperature in	c	e	g	c	e	g
June	—0.34	—0.52	—0.62	—0.13	0.04	—0.46
July	—0.52	—0.60	—0.66	0.51	—0.10	—0.59
August	—0.51	—0.63	—0.62	0.25	0.37	—0.61
September	—0.34	—0.20	—0.28	—0.27	0.59	—0.15
October	—0.33	—0.32	—0.22	—0.07	0.16	—0.09

The map fig. 9 only shows the amounts of larvae that are less than 10 mm. in length so as to give a picture of the relative importance of the spawning places.

It is seen at once that there is a close resemblance between the variations from year to year in the areas Odden-Djursland (c), the Belt Sea (e) and the western Baltic (f), particularly as regards the rich 1928 year-class, while the Sound differs from these areas by showing a rich year-class also in 1929; the fluctuation from year to year in the areas round Anholt (b) and N. of Sjælland (d) is quite different from that of areas c, e and f.

This also appears from a calculation of the correlation coefficient between the fluctuations of the different areas as shown in table 8.

The lengths of the larvae.

The mean lengths of the larvae of the autumn herring are given in table 7.

If we correlate the mean lengths of the herring larvae in the different areas, we get the figures given in table 9.

It is seen that in this way we get nearly the same picture as from the correlation between the quantities, except that area c (Djursland-Odden) shows less correspondence with area f (the western Baltic).

A remarkable fact is the low correlation between the areas N. of Sjælland (d) and the other areas. In area d the mean lengths in most years are much higher than in the other areas, which shows that at any rate only few of the larvae originate from the area but have drifted into the place. The extent of such a drifting in will of course vary from year to year from causes different from those leading to the fluctuations in the amount of fry.

The growth of the larvae of the autumn herring is shown in figure 11, and in figure 12 we find the growth at the different seasons together with spawning and hatching times.

Causes of fluctuation in the frequency of the year-classes.

The found fluctuations from year to year in the frequency of the herring larvae may be caused by the following factors:

(1) Insufficient investigations.
(2) Fluctuations in the amount of spawning herring.
(3) Fluctuations in the physical conditions influencing the development of the eggs or the thriving of the tiny larvae.
(4) Fluctuations in the nutrition of the tiny larvae or in the amount of animals feeding on the eggs or the tiny larvae.

The sufficiency of the investigations. The investigations are not in all cases fully sufficient to give a quite reliable mean figure for the amount of larvae, but the fact that the amounts of different areas to a very considerable degree vary in much the same way from year to year shows that the determinations as a whole are safe.

Fluctuations in the amount of spawning herring. If we compare the fluctuations from year to year in the amount of larvae of the autumn herring in the Belt Sea with the yield of the autumnal herring fishery in this area, as has been done in fig. 13, we find some correspondence. The yield of the herring fishery of course to some extent depends on the amount of herring. That the amount of larvae depends on the quantity of spawning herring I concluded in the case of the Bornholm herring from an investigation in 1927 on the fluctuations in the yield of the herring fishery at Bornholm between 1892 and 1914. This yield had varied comparatively regularly from year to year with a period of 3.7 years, which was nearly the average age of the spawning herring; this periodical variation of the yield must be supposed to be caused by the fact that a large amount of spawning herring, which gave heavy catches, produced a large amount of fry, which after another average period of 3.7 years once more gave many spawning herring and great yields of the fishery[1]).

The regular periodical variation in the yield of the herring fishery at Bornholm could also be established for the years 1919—30[2]).

[1]) Aage J. C. Jensen: On the influence of the amount of spawning herrings upon the following years. Journal du Conseil II, 1. 1927.

[2]) Aage J. C. Jensen: Periodic fluctuations in the size of various stocks of fish and their causes.—Medd. f. Komm. f. Danmarks Fiskeri- og Havunders. Serie Fiskeri, Bd. IX, 5. 1932.

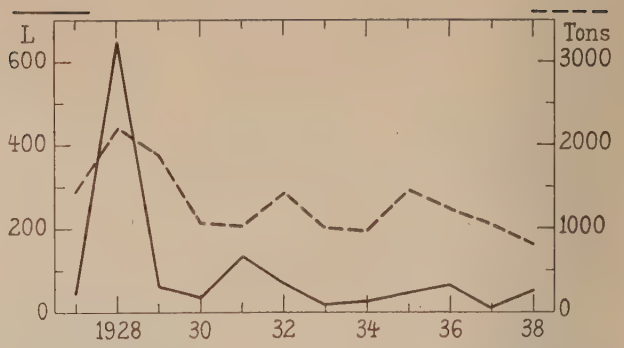

Figure 13. Numbers of larvae of autumn herring (L) caught per 30 minutes in the ring-trawl in areas c and e (E. of Djursland, northern part of the Belt Sea and the Great Belt) compared with the weight yields (in tons) of the herring fishery in the Belt Sea in July—December.

As regards the Sound herring A. C. Johansen in 1930 pointed out that the amount of larvae varied from year to year in the same way as the yield of the herring fishery[1]).

E. M. Poulsen also calls attention to this connexion[2]).

The physical conditions that may affect the, amount of herring larvae must primarily be current, salinity and temperature. The amount of oxygen must always be considered sufficient because the herring eggs are spawned in places where the renewal of the water is generally good.

The current to some extent can be measured from the salinity. The best way of comparing the variations from year to year in the amount of herring larvae with the variations in salinity and temperature is to calculate the correlation coefficient, which illustrates the correspondence between the two factors. This has been done in tables 10 and 11.

It is most natural to examine whether the amount of herring larvae fluctuates from year to year in the same way as the temperature or salinity of the water: as known a distinct connexion has been found to exist between the corresponding fluctuations in the strengths of the year-classes of both plaice and cod and these physical factors just after the spawning —connexions which must be explained from the

[1]) A. C. Johansen: On a correlation between the yearly catch of herring in the Sound and the abundance of herring larvae in autumn. Rapp. et Procès-Verb. LXXIV. 1930.

[2]) E. M. Poulsen: Yearly Variations in the Number of Larvae of Autumn Spawning Herrings in the Southern Part of the Transition Area. Rapp. et Procès-Verb. Vol. 100, 2. 1936.

facts that the amount of larvae of these fishes is determined partly directly by the temperature and conditions of current (and perhaps to some extent by the specific gravity), partly indirectly by these physical factors because they influence the amount of nourishment.

It appears from the tables that the surface temperature seems to show the more outspoken connexion with the fluctuations in the amount of larvae. This connexion was formerly pointed out by E. M. Poulsen[1]). The correlations with the surface salinity may be explained as a consequence of the connexion of the salinity with the temperature. In June-July a high surface temperature will mostly be accompanied by a low salinity, either on account of an inconsiderable mixing of the upper and lower water layers, or on account of prevailing easterly winds, and a low surface temperature will often accompany a high surface salinity during an intense mixing of the upper and lower water layers or on account of prevailing westerly winds.

At Schultz's Grund and Halskov Rev a high surface salinity, which indicates a comparatively slow outflow, during the immediately following time will be accompanied by a comparatively slow inflow in the lower water layer, i. e. by a low salinity at the bottom, while a low surface salinity is accompanied by a high bottom salinity.

It is seen, however, that the highest correlations with the surface temperature are found for July-August, i. e. about 2 months before the herring spawns.

The found connexion would be completely incomprehensible if it implied that the intensity of the spawning and hence the number of herring larvae were determined directly by the temperature: in this case it would be natural to expect the closest connexion with the temperature to be found at the time when the eggs or the tiny fry are found in the water. The explanation of the connexion most likely is that the spawning takes place later on when the temperature is too high and that the amount of larvae therefore grows small at the time when the investigations is carried out.

Another explanation possibly is that the temperature has an indirect effect on the quantity of larvae because it affects the biological conditions of the larvae. This possibility is discussed in the following.

[1]) E. M. Poulsen: l. cit. 1936.

Fluctuations in the nutrition of the tiny larvae. We have no or very few direct investigations on the amount of the organisms constituting the nourishment of the tiny herring larvae, but this amount must no doubt to a great extent be determined by the salinity and the temperature of the water. As regards the spring months A. C. Johansen has pointed out that the amount of plankton is highly dependent on these conditions[1]).

Of animals devouring the eggs our waters contain some gasteropods, the common star-fish and presumably some fishes. Inside Skagen the haddock, which in the North Sea eat large quantities of herring roe, are very rarely present in large numbers, and no instances are known, not even in the northernmost Kattegat, in which haddock have eaten, not to say overindulged in herring eggs like the so-called "spawny haddocks" of the North Sea. Star-fish and other invertebrate bottom animals may be so frequent in some localities of Danish waters that their influence is perceptible, but we have no measure of the variation from year to year in their numerical strength.

In the plankton many different animals are found to eat the tiny herring larvae, particularly *Pleurobrachia* and *Sarsia*.

It must be supposed that the quantities of these animals to a great extent are determined by the summer temperature of the water, and in many years they are so frequent that they are able to devour a very great part of the tiny herring fry.

Also the inflow determines the production of phytoplankton because the inflowing water contains nutritary salts while the water that has been standing in our waters for some time and the water emerging from the Baltic are nearly void of them. The deeper parts of the lower water layer of the central and southern Kattegat in summer and autumn also contain considerable amounts of phosphates and nitrates (Steemann Nielsen[2]), p. 10): a comparison of the variations in the volume of plankton at Halskov Rev with the salinities of the same locality shows a very distinct connexion. Here the heavy production did

[1]) A. C. Johansen: On the Fluctuations in the Quantity of Young Fry among Plaice and certain other Species of Fish, and Causes of the same. Rep. Dan. Biol. Stat. XXXIII. 1927.

[2]) E. Steemann Nielsen: Die Produktionsbedingungen des Phytoplanktons im Übergangsgebiet zwischen der Nord- und Ostsee. Medd. Komm. Danmarks Fiskeri- og Havunders., Ser. Plankton Bd. III, 4. 1940.

not occur until an inflow in the lower layer in summer brought in water with a salinity of nearly or more than 30 ‰. The production of phytoplankton determines the production of zooplankton; after a strong inflow of salt water in summer there must therefore be particularly large amounts of eggs and larval stages of planktonic crustacea and molluscs, which constitute the principal food of the tiny herring larvae.

Does the variation from year to year in the amount of larval autumn herring influence the yield of the herring fishery?

In table 12 the amounts of herring larvae in October within the area Djursland-Samsø Belt are correlated with the yields of the herring fishery of the second half-year in the Belt Sea and with the pound-net and drift-net fisheries from Hundested, Odden and Grenaa, where most of the herring catches from this area are landed. The seine and trawl fisheries, which mainly take quite small herring and the intensity of which varied highly in the different years, were not included. The average age of the herring taken in pound-nets and drift-nets is 3—4 years; therefore a considerable correspondence might be expected to exist between the variations from year to year in the amount of herring larvae and the variations in the yield of the herring fishery 3—4 years later. As will appear from the table there is but a slight indication of such a correspondence. However, there is a rather great though not very safe connexion with the yield in the Belt Sea 2 years later, but this connexion must be accidental. The calculations show that the fluctuations from year to year in the yield of the autumnal herring fishery depend on other causes than the amounts of larvae during the previous years. Among the factors that pre-eminently influence the yield of the autumn herring fishery must be mentioned partly the quantity of cod, which devour a large amount of young herring before the latter attain the sizes at which they are normally caught in pound- and drifts-nets, partly the temperature of the water in the first winter when the larvae are still small.

Table 12. The amount of herring larvae in autumn correlated with the yield of the herring fishery in the second half-year in the Belt Sea and from Hundested-Odden-Grenaa (H. O. G.).

	Belt Sea	H. O. G.
Yield in the same year	0.40	0.72
1 year later.....	0.43	0.47
2 years later	0.72	— 0.12
3 —	0.32	— 0.14
4 —	0.29	0.39
5 —	0.23	0.10

Tables I–VII.

Number and length distribution of herring larvae fished with 2 m ring-trawl in March–June 1927–39.

For each of the areas a—g (cp. the map Fig. 1) the length distributions of larvae (for each station calculated per 30 min. haul) during the various periods of investigations are arranged according to date (without regard to year). For the areas c and e also the total number in each fortnight have been shown.

Table I. Area a. Northwestern Kattegat.

	1933 9/4	1927 10-19/4	1934 14-27/4	1932 28/4	1930 30/4	1930 1/5	1927 4/5	1929 5-9/5	1930 18/5	1934 25/5	1928 22-23/6
Number of stations..	3	2	7	2	6	6	3	8	4	1	2
mm.											
9.....	..	..	..	..	..	..	..	..	2	..	..
10.....	..	..	1	..	..	..	1	..	..	..	..
11.....	1.5	..	3	..	..	..	..	..	..	2	2
12.....	..	..	1	..	..	..	..	..	..	2	..
13.....	1.5	..	8	..	..	2	1	..	..	4	..
14.....	..	..	7.5	2	..	2	1	3	..	6	..
15.....	..	..	13	6	2	..	..	3	..	2	..
16.....	..	..	17	..	2	..	..	..	..	2	..
17.....	..	..	39.5	2	2	2	..	1	..	2	..
18.....	..	..	61	4	..	10	..	..	..	2	..
19.....	..	1	43.5	2	6	10	3	1	..	4	..
20.....	..	..	54.5	..	..	2	2	..	..	1	..
21.....	..	..	50.5	..	..	..	..	..	..	6	..
22.....	..	..	37	..	4	..	..	..	..	8	..
23.....	..	..	16	..	..	..	..	..	..	8	..
24.....	..	..	6	..	..	..	..	..	..	4	..
25.....	..	..	1	..	..	..	..	..	..	4	..
26.....	..	..	..	..	..	..	..	..	..	2	..
27.....	..	..	..	..	..	..	..	..	..	..	..
28.....	..	..	..	..	..	..	..	..	..	2	..

Table III. Area c. Northern Belt Sea and E. of Djursla

	1936 1-3/4	1935 2-9/4	1927 6-7/4	1938 6-8/4	1931 8-9/4	1932 5-13/4	1933 9-11/4	1930 10-11/4	1937 10-13/4	1934 11-14/4	1929 16/4	1931 15-16/4	1936 15-17/4	1938 20-22/4	1939 22-27/4	1930 25-28/4	1937 26-27/4	1935 27-28/4	1931 28/4	1934 28/4
St.:....	11	13	6	6	6	10	6	7	7	9	3	4	5	8	14	7	3	4	2	1
mm.																				
6.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0.8	1.5	..	..	..	..
7.....	..	0.8	..	..	..	..	..	..	..	..	..	..	..	..	1.5	..	..	..	..	..
8.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3.8	..	..	..	..	0.5
9.....	0.8	3	..	3.8	..	..	1.5	..	5.3	..	..	..	1.5	..	13.5	..	1.5	..	..	0.5
10.....	5.3	1.5	..	14.3	10	..	2.5	..	4.5	1.5	..	..	..	..	23.3	1.5	3.8	..	..	1
11.....	10.5	6.8	..	21.5	10	1.5	..	..	11.3	..	..	..	..	..	24.8	..	3.8	..	..	1
12.....	15	3.8	..	18.8	12	4.5	1	5.5	11.3	4.5	..	5.5	..	1.5	33.8	1.5	3.8	..	..	2
13.....	15	..	1	15.8	10	2.5	..	19	23.3	13	..	4	..	1.5	9.8	..	7.5	..	1.5	..
14.....	12	..	..	6	12	6	1.5	36	16.5	21	..	4	0.8	5.5	9.8	3	3.8	..	1.5	0.5
15.....	6	..	6	7.5	3	5	..	34	11.3	25.5	..	2	..	..	8.3	1.5	12	..	..	0.5
16.....	9	..	9	0.8	..	4	2	23.5	1.5	31.5	..	2	..	..	9.8	1	12.8	..	..	0.5
17.....	..	0.8	9	0.8	..	1.5	..	7.5	..	37.5	1	..	..	..	3	3.5	9	1.5	1.5	3
18.....	..	1.5	9	3	..	1	..	1	..	36	1	..	..	..	0.8	3.5	1.5	..	..	0.5
19.....	0.8	..	8	1.5	..	..	..	..	..	20.3	..	..	..	..	..	1.5	0.8	..	..	..
20.....	..	..	..	..	..	..	..	..	..	14.3	..	..	..	..	..	..	..	..	..	..
21.....	..	..	3	..	..	..	..	..	..	17.3	..	..	..	..	..	..	..	..	..	..
22.....	..	..	1	..	..	..	..	..	..	1.5	..	..	..	..	..	..	..	..	..	..
23.....	..	..	..	..	..	..	..	..	..	0.8	..	..	..	..	..	..	..	..	..	..
24.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
25.....	..	..	..	..	..	..	..	..	..	0.8	..	..	..	..	..	..	..	..	..	..
26.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
27.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
28.....	..	..	..	..	..	..	..	..	..	0.8	..	..	..	..	..	..	..	..	..	..
29.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
30.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
31.....	..	..	..	..	..	..	..	..	..	0.8	..	..	..	..	..	..	..	..	..	..

Table II. Area b. Anholt area.

	1935 5-6/4	1937 13-15/4	1936 17-21/4	1938 22-24/4	1934 27-28/4	1930 28-30/4	1929 3-4/5	1933 6/5	1932 12/5	1930 19-22/5	1927 27-28/5	1931 6/6
Numb. of stat.:	8	10	8	7	4	10	9	2	4	11	2	3
mm.												
5.....	..	3	..	..	0.5	..	..	..	..	..	..	..
6.....	1.5	1.5	..	..	..	2	..	..	..	..	..	..
7.....	7.5	1.5	..	..	1	1.5	..	..	..	4.5	..	..
8.....	27	8.3	1.5	..	0.5	..	1	..	..	..	..	..
9.....	20.3	14.3	12	..	2.5	2.5	4	..	..	2	1	..
10.....	9.8	39	13.5	..	3.5	..	4	..	1.5	3	..	..
11.....	7.5	49.5	11.3	..	6.5	..	3	1	..	..	..	..
12.....	5.3	54	17.3	..	3	1.5	1	..	..	..	..	..
13.....	3	43.5	23.3	..	2	..	3	..	..	..	1	..
14.....	0.8	25.5	11	6	0.5	4	4	..	..	..	..	1
15.....	..	5.3	3.8	9.8	..	..	2	2	..	..	..	..
16.....	..	0.8	0.8	7.5	..	..	..	..	..	..	..	..
17.....	..	..	0.8	0.8	..	..	..	..	..	..	..	..
18.....	0.8	..	..	..	..	1.5	1	..	..	..	..	..
19.....	..	..	0.8	..	..	..	..	..	..	..	..	1
20.....	..	..	..	..	..	..	..	..	..	..	..	..
21.....	..	..	..	..	..	..	..	1	..	..	..	..
22.....	..	..	1.5	..	..	..	..	..	..	..	..	..
23.....	..	..	..	..	1	..	..	..	..	..	..	..

number of stations, n: number of years).

1933 4-8/5	1938 7-11/5	1937 8-13/5	1939 9/5	1934 15/5	1935 18-23/5	1927 19/5	1938 21/5	1930 22-26/5	1929 31/5	1929 1-3/6	1930 13-18/6	1927 17/6	1928 21/6	1934 23-24/6	1-15/4 n: 10	16-30/4 10	1-15/5 7	16-31/5 5	1-15/6 2	16-31/6 3
10	8	8	5	2	4	1	2	17	6	13	10	1	2	2	81	51	54	30	23	5
..	0.8	..	..	..	..	..	..	1.5	3	..	..	..	1	..	..	2.3	0.8	4.5	..	1
..	..	..	..	..	..	..	..	..	33	..	..	..	..	..	0.8	1.5	..	33	..	..
..	1.5	1.5	..	..	..	..	..	..	36	..	..	..	1	..	..	4.3	3	36	..	1
..	..	1.5	1.5	..	..	..	..	..	12	6	..	..	2	..	14.4	17	4	12	6	2
..	..	..	..	0.8	..	..	..	..	6	..	..	..	..	..	39.6	29.6	0.8	6	..	..
..	..	0.8	1.5	..	..	..	..	..	6	3	..	..	..	..	61.6	29.6	2.3	6	3	..
..	..	0.8	..	..	..	..	1.5	..	..	3	..	1	..	..	76.4	48.1	0.8	1.5	3	1
..	..	5.3	1.5	..	..	1	..	..	..	3	1	..	..	..	99.6	24.3	6.8	1	4	..
..	..	3	..	..	1	..	..	..	6	3	..	..	..	..	111.0	28.9	3	7	3	..
2	..	3.8	..	..	..	..	..	..	..	..	..	..	..	..	98.3	24.3	6.8	..	..	..
..	..	3.8	..	..	..	..	..	..	..	..	..	..	..	..	81.3	26.1	7.6	..	..	..
1	..	3.8	..	..	..	..	..	..	..	..	..	..	..	1	57.1	22.5	9.3	..	..	1
..	..	3	..	0.8	..	..	..	..	..	..	..	..	..	..	51.5	7.3	9.1	..	..	..
..	..	1.5	..	..	..	..	..	..	..	..	..	..	..	..	30.6	2.3	1.5	..	..	..
..	1.5	..	..	..	..	..	..	..	..	..	..	..	..	..	14.3	..	4.5	..	..	..
..	1.5	..	..	..	..	..	..	..	..	..	..	..	..	..	20.3	..	1.5	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2.5	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0.8	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0.8	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0.8	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0.8	..	..	..	..	..

Table IV. Area d. North of Sjælland. (Stat.: number of stations).

	1935 3-5/4	1930 8-9/4	1934 9/4	1937 15-16/4	1939 20/4	1936 21-22/4	1933 23-24/4	1938 24-25/4	1931 28/4	1929 28-29/4	1934 28-29/4	1935 28-29/4	1937 11-13/5	1939 12/5	1938 20-21/5	1937 29/5
Stat.:	6	4	4	9	5	6	8	6	4	12	3	4	5	1	3	5
mm.																
5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3
6	..	..	..	..	2.3	..	1	..	..	..	..	..	3.8	..	4.5	6
7	..	..	..	..	..	..	..	..	..	..	..	..	4.5	..	28.5	8.3
8	5.3	..	..	4.5	1.5	1.5	..	..	..	..	2	..	8.3	..	18	9
9	0.8	..	1.5	12.8	5.3	..	3	..	..	..	4	..	7.5	..	4.5	11.3
10	4.5	3	..	24	13.5	0.8	6	..	..	3	9.5	..	8.3	..	13.5	11.3
11	3	4.5	3.8	33.8	9	3	8	1.5	..	1	9	..	8.3	..	12	3
12	1.5	3	2.3	45.8	11.3	6	9	3	2	10	5	..	9	1.5	3	0.8
13	..	10.5	2.3	68.3	12	5.3	9	..	3.5	..	2.5	..	9.8	..	3	..
14	..	25.5	0.8	66.8	8.3	2.3	4	1.5	6	..	0.5	3.8	4.5	..	1.5	..
15	..	3	0.8	49.5	2.3	1.5	4	3.8	..	1	0.5	..	4.5	..	..	..
16	..	3	..	36	0.8	1.5	2	5.3	..	..	..	0.8	1.5	..	..	..
17	3	..	..	4.5	..	..	3	0.8	3	..	..	..	..	..	..	..
18	..	..	..	1.5	1.5	0.8	..	0.8	..	..	..	..	..	..	..	..
19	..	..	..	3.8	..	..	..	0.8	..	..	..	..	..	..	..	..
20	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
21	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
22	..	..	..	..	..	..	..	0.8	..	..	..	..	..	..	..	..
23	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
24	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
25	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
26	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
27	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
28	..	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table V. Area e. Great Belt (St.: number of stations).

	1927 1-10/3	1931 11/3	1930 1-4/4	1932 4-8/4	1927 4-10/4	1938 5-12/4	1936 4-14/4	1937 8-10/4	1933 11/4	1935 10-15/4	1930 14/4	1931 9-25/4	1932 20/4	1937 21-28/4	1938 20-29/4	1930 24-25/4	1936 26-27/4
St.:	8	2	14	7	5	9	14	4	2	12	7	12	2	11	7	5	4
mm.																	
5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	13.5	..	..
7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	33	..	..
8	..	..	..	..	..	..	..	..	..	..	..	..	..	..	21	..	..
9	..	1	..	..	..	0.8	..	1.5	..	..	..	..	..	..	6.8	..	..
10	..	..	..	1.5	..	6.8	..	0.8	0.8	..	..	1	..	..	1.5	..	..
11	..	..	..	..	..	1.5	..	3	..	2.3	..	..	..	..	..	..	..
12	2.5	..	1.5	6	..	1.5	1.5	1.5	1.8	2.3	1	5	..	1.5	..	..	..
13	8.5	..	..	4.5	..	0.8	3	2.3	..	1.5	1	2	..	2.3	1.5	1	..
14	16.5	..	8.5	3	3	0.8	5	0.8	3.8	..	5	7	..	2.3	..	..	..
15	12.5	..	8	..	2	0.8	4.5	0.8	3	0.8	5	17	..	3.8	..	2	..
16	9	..	..	..	4	0.8	3.8	1.5	3	..	4.5	7	2	1.5	1.5	3	..
17	3	..	..	..	20	..	1.5	0.8	..	0.8	7.5	3	..	2.3	..	4	..
18	..	..	..	..	10	..	..	..	..	4.5	2	2	..	..	..	3	..
19	..	..	..	..	5	..	0.8	..	..	..	..	..	..	..	..	1	1.5
20	1	..	..	..	3	..	..	..	..	..	..	..	..	..	..	..	..
21	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
22	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
23	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
24	..	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
25	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
28	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..	..	..
29	..	..	..	..	..	..	..	..	..	..	..	1.5	..	..	..	..	..
31	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
32	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
36	0.5	..	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table VI. Area f. Lesser Belt and western Baltic.

	1932 6-7/4	1927 8-10/4	1938 9-12/4	1935 12-14/4	1929 15-16/4	1931 16/4	1937 17-21/4	1937 23-26/4	1939 28-29/4	1936 28-30/4	1939 17-24/5	1929 28-30/5	1930 11-14/6
Number of stations	6	7	5	12	6	5	9	6	7	7	15	21	8
mm.													
5	..	..	..	..	..	..	..	..	..	..	..	..	1
6	..	..	..	..	..	..	..	..	1.5	..	1.5	..	11
7	..	..	..	..	..	..	..	..	1.5	..	4.5	14	13
8	..	..	..	..	..	..	..	..	4.5	..	12	21	10
9	..	..	..	..	..	..	..	..	6	..	4.5	7.5	7
10	..	..	1.5	..	..	3	..	..	5.3	..	4.5	3	2
11	..	..	7.5	..	..	..	..	..	0.8	..	2.3	12	1
12	..	..	6	..	..	..	..	0.8	2.3	..	2.3	18	..
13	..	..	6	1	..	..	3	0.8	0.8	..	0.8	3	1
14	..	..	7.5	..	..	..	3	..	0.8	..	..	..	..
15	..	1	1.5	1	..	..	3	7.5	1.5	1.5	..	3	..
16	..	2	..	..	1.5	..	..	4.5	..	1.5	..	..	1
17	..	1	..	..	1.5	..	..	1.5	0.8	3.8	..	..	..
18	..	3	..	..	..	..	..	3	..	1.5	..	..	..
19	..	1	..	..	..	..	..	1.5	..	..	..	..	..
20	..	..	..	..	..	..	..	..	..	..	..	..	..
21	1.5	..	..	..	..	..	..	..	..	..	..	..	..
22	1	..	..	..	..	..	..	..	..	..	..	..	..
23	..	..	..	..	..	..	..	0.8	..	..	..	..	..
24	..	..	..	..	..	..	..	..	..	..	..	..	..
25	..	..	..	..	..	..	1.5	..	..	..	..	..	..
26	3.5	..	..	..	..	..	..	..	..	..	0.8	..	..
27	..	..	..	..	..	..	1	..	..	..	..	..	..
28	..	..	..	..	..	..	..	..	..	..	..	..	..
34	..	..	..	..	..	..	1	..	..	..	..	..	..

Table V continued. (n: Number of years).

	1939 30/4	1939 8/5	1933 4-11/5	1934 14-19/5	1928 18/5	1929 12-27/5	1939 18-25/5	1929 5/6	1927 11/6	1928 9-19/6	1930 11-13/6	1-15/3 n: 2	1-15/4 8	16-30/4 8	1-15/5 2	16-31/5 4	/6 4
St.:	3	2	7	6	3	30	9	3	1	7	15	10	67	51	9	48	26
mm.																	
5	3	..	..	..	..	..	..	..	..	..	..	..	..	3	..	..	..
6	..	..	..	..	1	15	..	..	..	3,5	..	..	..	13.5	..	16	3,5
7	3	..	..	..	..	186	..	..	..	15	6	..	..	36	..	186	21
8	..	..	..	..	..	186	..	..	..	5	4	..	..	21	..	186	9
9	1.5	..	..	2	..	87	..	..	..	2.5	2	1	2.3	8.3	..	89	4.5
10	1.5	..	..	0.5	..	30	..	..	..	1	..	..	9.9	4	..	30.5	1
11	..	..	..	..	..	36	..	..	..	..	..	..	6.3	..	..	36	..
12	..	..	..	..	..	78	1.5	1.5	..	1	3	2.5	16.1	7.5	..	79.5	5.5
13	..	..	..	..	..	75	1.5	1.5	..	..	..	8.5	12.1	7.8	..	76.5	1.5
14	..	..	1	..	..	24	0.8	..	..	..	..	16.5	24.9	14.3	1	24.8	..
15	..	..	..	..	..	3	1.5	..	1	..	..	12.5	19.9	25.8	..	4.5	1
16	..	..	..	..	..	..	..	..	..	..	..	9	13.1	16.5	..	..	..
17	..	3	..	..	..	..	..	..	..	..	..	3	23.1	12.8	3	..	..
18	..	1.5	..	..	..	..	..	..	..	..	..	..	14.5	7	1.5	..	..
19	..	..	1	0.5	..	..	1.5	..	..	..	..	..	5.8	2.5	1	2	..
20	..	..	..	..	..	..	0.8	..	..	..	..	1	3	..	..	0.8	..
21	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	1	..
22	..	..	..	..	..	..	0.8	..	..	..	..	..	..	..	..	0.8	..
23	..	0.8	..	..	..	..	..	..	..	..	..	..	..	..	0.8	..	..
24	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
25	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	1
28	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..
29	..	..	..	..	..	..	..	..	..	..	..	..	..	1.5	..	..	..
31	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..
32	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..
36	..	..	..	..	..	..	..	..	..	..	..	0.5	3	..	..	..	..

Table VII. Area g. The Sound-Møen area.

	1934 7-8/4	1935 13/4	1932 15-19/4	1939 17/4	1937 17-20/4	1936 22-25/4	1933 24-29/4	1929 25-27/4	1938 25-28/4	1931 30/4	1935 1-3/5	1931 3-13/5	1939 13-17/5	1938 15-19/5
Number of stations.....	5	4	18	5	10	11	16	5	7	2	11	7	12	12
mm.														
5.....	..	..	..	1.5	..	..	..	..	..	..	..	..	..	..
6.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..
7.....	..	..	..	0.8	..	..	..	2	..	..	..	..	..	..
8.....	..	..	..	..	..	..	..	..	..	..	..	..	..	1.5
9.....	..	..	..	12.8	..	..	..	..	..	..	..	..	..	..
10.....	..	1.5	..	8.3	1.5	..	..	..	0.8	..	1.5	1.5	..	..
11.....	0.8	..	..	10.5	1.5	1.5	..	..	0.8	..	..	1.5	..	..
12.....	..	..	..	18	1.5	4.5	2	1	..	..	1.5	..	..	..
13.....	0.8	..	..	22.5	0.8	..	..	..	0.8	..	1.5	..	..	..
14.....	..	..	2	17	3.8	0.8	..	..	..	8	1.5	1.5	..	..
15.....	0.8	..	..	7.5	8.3	0.8	..	..	0.8	4	1.5	..	..	..
16.....	..	..	1	3	3.8	0.8	4	2	1.5	2	3	..	..	..
17.....	..	..	..	..	0.8	..	..	..	0.8	..	1.5	..	..	..
18.....	..	..	..	..	0.8	2.3	..	..	..	..	..	..	..	..
19.....	..	..	..	1.5	..	..	..	1	..	..	1.5	..	..	..
20.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..
21.....	..	..	..	..	..	..	..	..	..	..	..	..	1.5	..
22.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..
23.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..
24.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..
25.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..
26.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..
27.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..
28.....	..	..	..	1.5	..	..	..	..	..	..	..	..	..	..
29.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..
30.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..
31.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..
32.....	..	..	..	..	0.8	..	..	..	..	..	..	..	..	..

88 pp. IV. *The same:* Appendix to Report XXI. With 2 Charts. 7 pp. On the distribution of the Animal Communities on the Sea Bottom. 1914.

XXIII. *C. G. Joh. Petersen:* On the Animal Communities of the Sea Bottom in the Skagerak, the Christiania Fjord and the Danish waters. With one Chart and four Tables. 29 pp. 1915.

XXIV. I. *C. G. Joh. Petersen:* On the Development of our Common Gobies (*Gobius*) from the Egg to the Adult Stages etc. With 1 Plate and 3 Figures in Text. II. *H. Blegvad:* On the Food of Fish in the Danish Waters within The Skaw. 72 pp. 1916.

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Printed by Bianco Luno, Copenhagen.